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	First Named Inventor	Stephen Richard COULSON
	Art Unit	1767
	Examiner Name	NICOLE M. BUIE-HATCHER
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1	Guimond et al., "Influence of gas phase and surface reactions on plasma polymerization", Surface & Coatings Technology, Vol. 205, Supplement 2, Pages 447-450, 2011, (4 pages).
2	Yasuda, "Plasma Polymerization", Academic Press, Inc., Orlando, Florida, 1985, (22 pages).
3	Declaration of Gregory N. Parsons, PH.D., Exhibit 2001, Case IPR2020-01198, filed October 30, 2020, (109 pages).
4	Patent Owner's Preliminary Response, Case IPR2020-01198, filed October 30, 2020, (70 pages).
5	Patent Owner's SUR-Reply to Petitioner's Reply to Preliminary Response, Case IPR2020-01198, filed December 8, 2020, (9 pages).
6	Petitioner's Reply to Patent Owner's Preliminary Response, Case IPR2020-01198, filed December 1, 2020, (8 pages).

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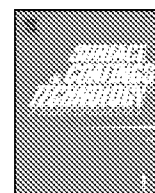
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Influence of gas phase and surface reactions on plasma polymerization

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ABSTRACT

The formation of plasma polymers is based on multistep reactions that are taking place both in the gas phase and on the surface of the growing film. In order to gain more insights and to control plasma polymerization processes, some assumptions can be made that allow a macroscopic description. Following this idea, a concept was developed based on the energy input both into the gas phase (plasma) and during film growth (surface) that helps in up-scaling plasma polymerization processes. In order to test this concept, various a-C:H:N thin films were deposited under different $\text{NH}_3/\text{C}_2\text{H}_4$ gas ratios, power inputs W , and gas flow rates F . Thereby, the energy consumed in the gas phase is controlled by W/F yielding a flux of film-forming species. The comparison of two comparable plasma reactors of different sizes indicate that while the reaction parameter W/F plays a major role for the transfer of plasma polymerization processes, the energy input into the film by ion bombardment during film growth should also be taken into account.

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1. Introduction

The deposition of functional plasma polymer thin films enables the adjustment of surface properties for different applications such as hydrophilic textiles with improved sweat management or cytocompatible materials for tissue engineering [1–3]. Industrial applications require reliable and manageable processes, which can be transferred to production-scale reactors [4]. This often has a strong influence on the choice of process gasses and reactor geometry, for instance. Moreover, plasma polymers optimized with respect to functionality and stability in aqueous environments are often required [5]. Due to the enormous difficulties lying in the microscopic description of plasma polymerization processes, we are considering a macroscopic approach which is based on the energy input into the plasma process [6–8]. Since plasma polymerization processes involve both gas phase reactions and surface reactions, it is important to consider the energy input into the plasma zone as well as the energy input into the film itself. While the former gives the energy invested per particle within the active plasma zone, the latter is mostly related to ion bombardment at the growing film surface. Both reaction parameters are mainly determined by the external parameters power input W and unit of gas flow F when some internal parameters such as power absorption, direction of gas flow, plasma expansion, plasma density, and sheath potential are known.

Assuming that the film growth is limited by the activation of the monomer in the gas phase (reaction kinetics limited regime), i.e. it is

not determined by diffusive transport or high overall conversion, a quasi-Arrhenius relation can be used to describe the mass deposition rate per unit of gas (monomer) flow R_m/F as a function of the specific energy input W/F as reaction parameter:

$$\frac{R_m}{F} = G \exp\left(-\frac{E_a}{W/F}\right), \quad (1)$$

where E_a represents an apparent activation energy (activation barrier) and G is a reactor and process dependent factor related to the maximum monomer conversion into film growth [9–12].

The energy dissipated in the film during growth, on the other hand, is approximated by the energy density ε (in eV nm^{-3}):

$$\varepsilon = \frac{\Gamma_i E_{\text{mean}}}{R}, \quad (2)$$

which represents ion bombardment (ion flux times mean ion energy) per film growth rate R (in nm s^{-1}) [13]. The ion flux Γ_i incident on the substrate (in $\text{nm}^{-2} \text{s}^{-1}$) can be estimated using a model proposed by Lieberman et al. [14]:

$$\Gamma_i = n_0 v_B \cos \theta \quad (3)$$

with n_0 being the plasma density in the plasma bulk (which equals the electron density n_e for electropositive gasses) and v_B , the Bohm velocity of the ions entering the plasma sheath. The reduction of the number of ions fulfilling the Bohm criteria due to collisions is considered by the factor $\cos \theta$ which in turn depends on the plasma length and the ion mean free path — it is roughly 0.2 for the plasma conditions considered here (pressure of 10 Pa). The mean energy

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E_{mean} of the ions impinging on the substrate (in [eV]) can be estimated from the sheath potential V_s according to a study by Manenschijn and Goedher [15]:

$$E_{mean} = eV_s \cos \varphi, \quad (4)$$

where the factor $\cos \varphi$ regards collisions in the plasma sheath and depends on the sheath length, the ion mean free path and the type of collisions (elastic or charge-exchange). For the considered plasma conditions (pressure of 10 Pa) it is roughly 0.15. The sheath voltage is proportional to the excitation voltage with $V_s = 0.39 V_0$ for symmetric RF discharges [14]. Hence, measuring the electron density and the excitation voltage (which both depend on power input W , but not on flow rate F) as well as the deposition rate enables the calculation of the energy density according to Eqs. (2)–(4).

A macroscopic approach has thus been used in this work to investigate plasma polymerization processes for the deposition of amine-functional a-C:H:N coatings that can also be transferred to industrial reactors [8,16].

2. Experimental

Two different reactors were used to investigate the transfer of plasma polymerization processes: a lab-scale batch reactor and a pilot-scale web coater (Fig. 1). The (symmetric) batch reactor is composed of two plane parallel electrodes of the same size (30 cm in diameter) separated by a glass cylinder [16]. The distance between the upper showerhead electrode and the lower RF-driven (13.56 MHz) electrode was 5 cm. The pressure was fixed at 10 Pa, while the power input was varied between 7 and 150 W. The monomer flow rate of ethylene (C_2H_4) was held constant at 8 sccm. Beside pure C_2H_4 discharges, ammonia (NH_3) was added with 8 and 16 sccm to obtain gas ratios of NH_3/C_2H_4 of 1:1 and 2:1. The web coater consisted of a RF-driven (13.56 MHz) drum electrode (with a diameter of 59 cm and a length of 65 cm) enclosed in a larger cylindrical vessel [17,18]. The substrates were fixed on the drum which was rotated during plasma deposition. The gas inlet was distributed at four positions (showerhead) around the drum to obtain a homogeneous gas flow. The power input was varied between 300 and 1000 W at a pressure of 10 Pa. The following gas flow rates were used: 100 sccm C_2H_4 (pure C_2H_4 discharge), 250 sccm C_2H_4 with 250 sccm NH_3 ($NH_3/C_2H_4 = 1:1$), and 100 sccm C_2H_4 with 250 sccm NH_3 ($NH_3/C_2H_4 = 2.5:1$). Due to the (nearly) symmetric set-up of the electrodes in both reactors, the bias voltage remained small and the discharge homogeneously occupied the whole inter-electrode space allowing for the comparison of both reactors.

The deposited mass was measured by weighing thin glass slide substrates right before and after deposition, while profilometry was used to determine the film thickness. The film density was simply calculated from both values. A V/I probe (ENI Model 1065) was used to measure excitation voltage V_0 and absorbed power W (the latter had a value around 80% of the generator's nominal power). Electron densities were measured within the batch reactor using microwave

interferometry (JE PlasmaConsult MWI 2650) by integrating over the line of sight with a plasma length of 28 cm (see Fig. 1). The method is based on the phase shift of 26.5 GHz microwave radiation transmitted through the plasma [19]. Fig. 2 displays the obtained electron densities, which show a linear dependence over a broad range of power input, thus showing reliable plasma conditions. Since the electron density could not easily be measured for the web coater (due to technical reasons), we did a comparison based on the power input per plasma volume, the latter being roughly 66,000 cm³ for the web coater and 1850 cm³ for the batch reactor. XPS surface analysis was performed in a PHI 5600 LS system, using a non-monochromatized MgK α source and an electron take-off angle of 45°. All samples were analyzed within one day following their deposition. The surface concentration of primary amines, $[-NH_2]$, was determined by XPS after derivatization with 4-(trifluoromethyl)benzaldehyde (TFBA) vapor [26].

3. Results and discussion

We have recently investigated the plasma polymer growth from CO_2/C_2H_4 discharges with varying gas ratio and flow rates [7,11]. We found that the evolution of the deposition rate as a function of the reaction parameter W/F follows an Arrhenius-like behavior according to Eq. (1) over a broad parameter range. This range was named regime II (reaction kinetics limited range), while regime I shows deviations from the Arrhenius-like behavior at low energy input and regime III is indicated by deviations at the high energy side [7]. Similar results were obtained for NH_3/C_2H_4 discharges as shown in Fig. 3 and as already reported in the literature [21–23]. While examining a broad range of W/F within the batch reactor, the three regimes including the linear Arrhenius-like regime can clearly be seen for the NH_3/C_2H_4 gas ratio of 1:1. With increasing gas ratio, the deposition rates were found to be reduced compared to pure C_2H_4 discharges, which is ascribed to formation of CN and HCN species in the gas phase yielding incorporation of nitrogen as well as chemical etching during film growth. Nevertheless, the deposition of the a-C:H:N coatings is mainly described by an Arrhenius-like behavior (regime II). Therefore, we assume a similar reaction pathway over a broad range of energy input, where mainly the number of film-forming species is increased. The chemical reaction pathway might proceed via film-forming species which show a high sticking coefficient, but a low to moderate reactivity in the gas phase [24]. Thus, specific reaction channels might be promoted despite of unselective plasma-chemical processes in the gas phase. Moreover, the surface elemental composition of the a-C:H:N plasma polymers was found to be approximately constant within this regime, e.g. $N/C = 0.24 \pm 0.02$ for $NH_3/C_2H_4 = 1$ (agreeing well with data obtained by others [25]), while the N content is reduced for regime III.

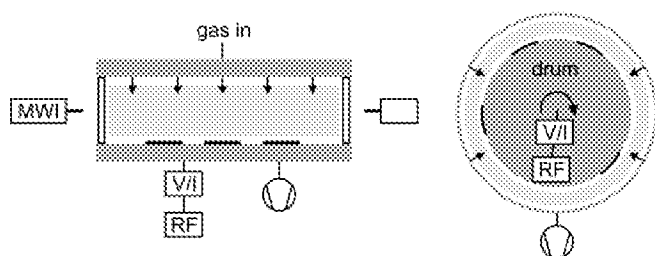


Fig. 1. Scheme of the batch reactor (left) and the web coater (right) experimental set-ups. Substrates were placed on the driven electrode in both cases.

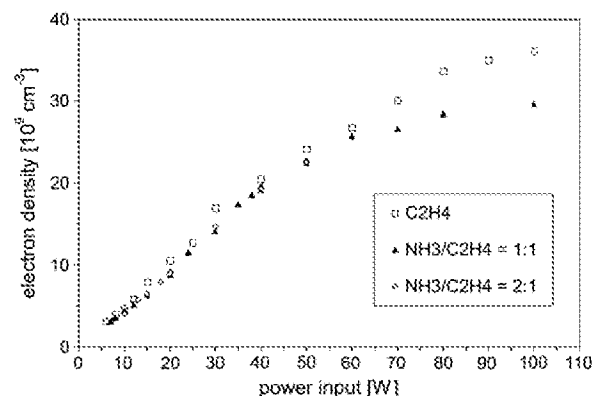


Fig. 2. Electron density measured as a function of power input for the batch reactor.

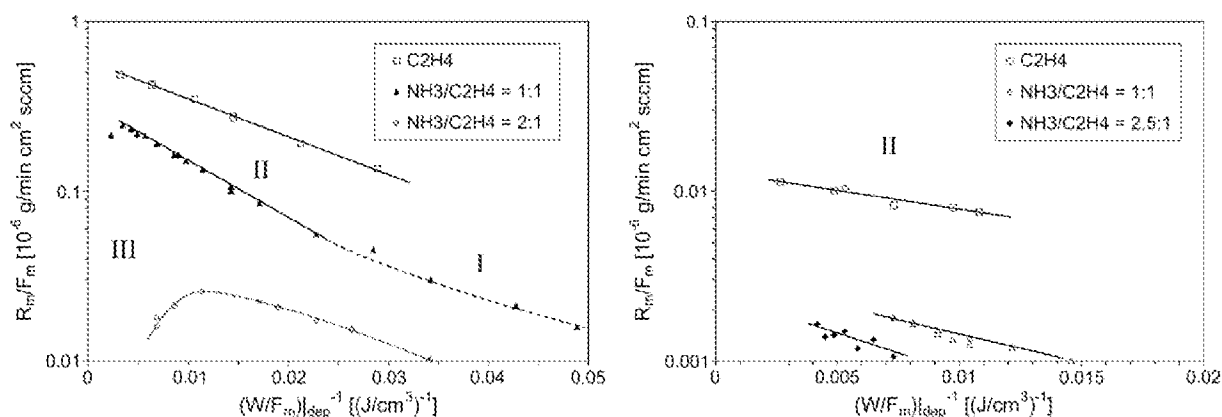


Fig. 3. Arrhenius-like plots of the deposited mass vs. the inverse energy input for $\text{NH}_3/\text{C}_2\text{H}_4$ and C_2H_4 discharges as obtained in the batch reactor (left) and the web coater (right). The different regimes are indicated by roman numbers.

The plasma polymerization performed in the web coater showed very similar results regarding regime II (Fig. 3). Corrected for the actual energy input into the plasma volume, the same slopes of the Arrhenius fits were obtained in both reactors for C_2H_4 and $\text{NH}_3/\text{C}_2\text{H}_4 = 1:1$ (51 J cm^{-3} or 12 eV per particle and 75 J cm^{-3} or 18 eV per particle, respectively) [26]. Note that for the curve of $\text{NH}_3/\text{C}_2\text{H}_4 = 1$ in the web coater a higher monomer flow (250 sccm as compared to the pure C_2H_4 discharge with 100 sccm) was used, resulting in lower R_m/F_m values. This is attributed to the fact that the absolute deposition rates are also limited by surface reactions (e.g. formation of nucleation sites and incorporation of incoming film-forming species) [11].

For higher $\text{NH}_3/\text{C}_2\text{H}_4$ gas ratios, however, a different evolution of the deposition rate can be observed between the two reactors. While the web coater data for $\text{NH}_3/\text{C}_2\text{H}_4 = 2.5:1$ still follow Eq. (1) (with $E_a = 112 \text{ J cm}^{-3}$ or 26 eV), a flattened curve appeared for $\text{NH}_3/\text{C}_2\text{H}_4 = 2:1$ in the case of the batch reactor. A similar behavior was already observed for higher $\text{NH}_3/\text{C}_2\text{H}_2$ gas ratios in the web coater and for a $\text{CO}_2/\text{C}_2\text{H}_4$ gas ratio of 6:1 in the symmetric batch reactor [11,21]. We ascribed this effect to a stronger influence of ion bombardment in the batch reactor. In order to verify this assumption, we calculated the energy density ϵ during deposition according to Eq. (2) by measuring excitation and bias voltage as well as electron densities assuming electropositive plasmas.

For the batch reactor and $\text{NH}_3/\text{C}_2\text{H}_4 = 1$, we obtained values of ϵ around 1000 eV nm^{-3} (corresponding to $\sim 15 \text{ eV}$ per deposited C or N atom) yielding crosslinking and densification of the films, whereas a deviation from the Arrhenius curve appeared at $\epsilon > 2000 \text{ eV nm}^{-3}$ (for $(W/F)^{-1}$ values below $0.003 (\text{J/cm}^3)^{-1}$, see Fig. 3). For the higher

$\text{NH}_3/\text{C}_2\text{H}_4$ gas ratio of 2:1, the energy density was constantly above this value, thus supporting the view of ion-induced etching effects. This also explains the increasing film density for higher $\text{NH}_3/\text{C}_2\text{H}_4$ gas ratios as reported in Ref. [1]. We note here that the density of the films scales more or less linearly over a broad range of $\log \epsilon$ (Fig. 4).

Since we could not measure the electron density within the web coater, we assumed in a first approach to have the same values as in the smaller batch reactor when comparing power input per plasma volume yielding comparable excitation voltages V_0 for both reactors. Note that our macroscopic approach to examine the plasma chemical gas phase processes also enables the comparison of different plasma reactors based on the energy input (W/F) per plasma volume (active plasma zone). However, the obtained values did not match with the measured film densities for both reactors as indicated by the surrounded small dots in Fig. 4. A satisfying match can only be obtained if we assume that the electron densities are actually lower in the web coater, which indicates the importance of plasma reactor geometry (even though the voltage drop through the plasma sheath was comparable for both reactors, i.e. around 100–200 V). A good match could be obtained assuming a four times lower plasma density in the web coater, as shown in Fig. 4. This assumption is based on the observation that film density scales with energy density [27,28]. Moreover, the phase shift between voltage and current was found to be -78° in the web coater instead of -88° for the batch reactor. Thus, the current density, which scales with electron density, is smaller within the larger reactor (for comparable W/F and V_0) [29,30]. The possibility that the energy dissipated in the film (by ion bombardment) during growth is actually much lower in the web coater

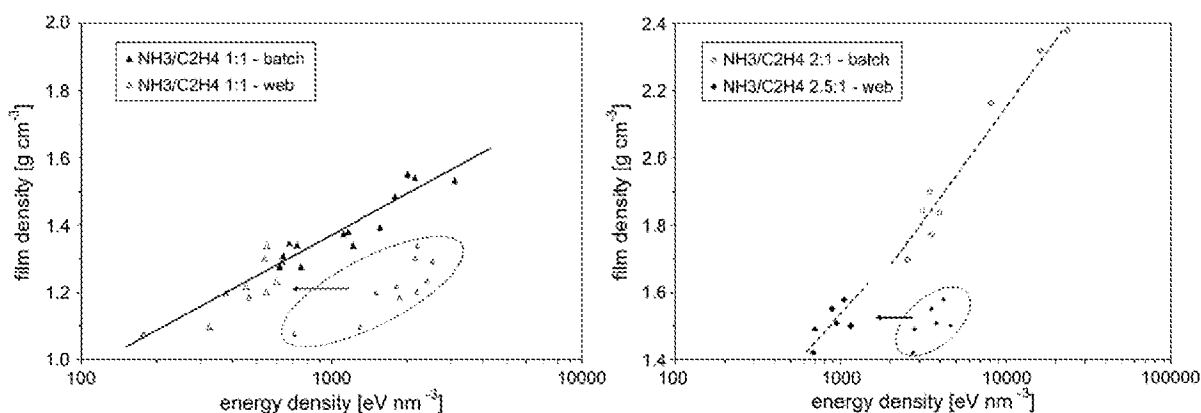


Fig. 4. Film density of a-C:H:N coatings as obtained for the two reactors depending on the energy density during film growth for $\text{NH}_3/\text{C}_2\text{H}_4$ gas ratio of 1:1 (left) and 2:1/2.5:1 (right). The energy density in the web coater is adjusted to agree with the film density values for both reactors (see text).

compared to the batch reactor would also explain the obtained differences in the deposition rates for higher $\text{NH}_3/\text{C}_2\text{H}_4$ gas ratios.

These observations show that beside the specific energy input into the gas phase, the energetic conditions (ions and fast neutrals impinging the surface) during film growth should also be considered for up-scaling plasma polymerization processes. Nevertheless, as long as the deposition follows an Arrhenius-like behavior (regime II), the film elemental composition (C, N, and O) is mainly determined by gas phase processes yielding the flux of film-forming species. For the web coater we obtained a-C:H:N coatings with a constant N concentration over the whole regime II ($\text{N/C} = 0.24 \pm 0.02$ for $\text{NH}_3/\text{C}_2\text{H}_4 = 1$). The deposited mass thus corresponds to the particle flux of the film-forming species originating from the active plasma zone (chemical reaction pathway). The amount of amino groups ($-\text{NH}_2$), however, was found to decrease with increasing energy density, i.e. crosslinking (from 0.1 to 0.01 for NH_2/C), which will be published in more detail elsewhere. Nitrogen-containing plasma polymer films can thus be optimized regarding their crosslinking (film density), deposition rate and functionality by using the presented macroscopic approach.

4. Conclusions

$\text{NH}_3/\text{C}_2\text{H}_4$ discharges were investigated within a lab-scale and a pilot-scale reactor using a macroscopic approach regarding their deposition rates depending on power input and (monomer) flow rate. The reaction parameter W/F was found to support the transfer between the two reactors for the deposition of amine-functional plasma polymers. However, the film growth is also determined by the energy dissipated at its surface during the deposition given by ion flux times mean ion energy per deposition rate, which can be estimated for both reactors assuming that the film density scales with the energy density. Thus, lower plasma densities were found for the larger web coater, which might be caused by lower current densities, showing the importance of taking into account plasma geometry for up-scaling.

Acknowledgments

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PLASMA POLYMERIZATION

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Preface

Plasma polymerization is a new material preparation *process* and is not a kind of polymerization. The materials formed by plasma polymerization are vastly different from conventional polymers and constitute a new kind of material. Plasma polymerization has been dealt with, however, as an extension of polymerization from the academic viewpoint and as a new technology to prepare thin films from a practical viewpoint. There seems to be a great conceptual gap between these two approaches, which hampers true understanding of plasma polymerization and thorough utilization of the technology. This book is intended to bridge the gap so that the significance of plasma polymerization in materials science and technology can be recognized and its merit fully utilized in the modern technologies concerned with materials.

Plasma polymerization covers a wide interdisciplinary area of physics, chemistry, interfaces, materials, and so on. Scientists and engineers in different disciplines have contributed to advance the knowledge on plasma polymerization, but without thorough understanding of aspects involved in disciplines other than their own. Consequently, the interpretation of phenomena has been largely dictated by the disciplinary background of the investigator, and the very process of forming polymeric materials has been left more or less as a black box. Although this black box is a major subject of this book, it is also intended to cover fundamental knowledge in different subject areas necessary to grasp plasma polymerization overall. The major topics covered are gas-phase kinetics (Chapter 3), ionization of gases (Chapter 4), fundamentals of polymerization (Chapter 5), mechanism of polymer formation in plasma (Chapter 6), competitive aspects of polymer formation and ablation (Chapter 7), mechanism of polymer deposition (Chapter 8), operational factors of plasma polymerization (Chapter 9), general characteristics of plasma polymers (Chapter 10), and electrical properties of plasma polymers (Chapter 11).

Plasma polymerization is a highly system dependent process. Therefore, without comprehension of this aspect, interpretation of experimental data does not go beyond the boundary of experimental conditions employed in a particular experiment, and the generalization of findings may not be justified or is often

misleading. The interpretations presented in this book are strictly on the basis of the author's view. The chronological citation of literature is intentionally avoided. Instead, the author took the liberty of interpreting all data in a consistent manner in order to avoid accumulating sporadic and noncoherent information.

Plasma polymerization is an ultra-thin-film processing technology and covers very important subject areas that can be recognized as comprising the vacuum deposition of covalently bonded materials. Some of these subject areas have been dealt with under terms such as chemical vapor deposition, plasma-assisted chemical vapor deposition, and so on, in most cases dealing with formation of inorganic materials. Principles described in this book doubtless will be applicable to these relatively new processes. It is the author's view that these new processes and plasma polymerization will emerge as an integrated technology that will penetrate much deeper, over a wider area of materials science, than they would if exploited separately. The author hopes that this book will contribute to the conceptual background for this new group of materials and the processes by which they are prepared.

The author wishes to acknowledge all his colleagues in this subject area for providing valuable information. Special thanks are due to my family, my wife Gerda and my children Ken, Akira, and Lisbeth, for their understanding and sacrifice, which made the preparation of this book possible.

CHAPTER 1

Introduction

Plasma polymerization refers to the formation of polymeric materials under the influence of plasma (partially ionized gas). Because the most practical means of carrying out plasma polymerization involves the use of an electric glow discharge in a vacuum, the term glow discharge polymerization has been used, in every practical sense, synonymously with plasma polymerization, although plasma polymerization can be carried out by means other than glow discharge.

It was known for many years that some organic compounds form solid deposits in plasma generated by some kind of electrical discharge (1-9). In most cases, however, the deposits were recognized as by-products of phenomena associated with electric discharge; consequently, little attention was paid either to the properties of these materials (undesirable by-products) or to the process as a means of forming useful materials.

At these early stages of discovery, the concept of polymers was not well developed, and obviously these processes had never been considered to be polymerization, that is, plasma polymerization or glow discharge polymerization. Only since the 1960s has the formation of materials in plasma been recognized as a means of synthesizing polymers, and the process, when used to make a special coating on metals, has been referred to as plasma polymerization or glow discharge polymerization (10-14).

Following the advancement of polymer science, the formation of organic solids or films in plasma has attracted considerable attention, and the process has been generally recognized as plasma polymerization or glow discharge polymerization. The American Chemical Society has held symposiums (1970, 1974, 1978, and 1982) on this subject.

In these developments (i.e., up to the 1970s), however, the concept of plasma polymerization has been based on the application of the concept of polymerization and/or of polymers developed in preceding decades to the formation of organic material under plasma conditions. In other words, the process has attracted the attention of scientists and engineers as an exotic method of polymerization. Although a great number of research studies have

been published and numerous potential applications and the uniqueness of the polymer formation process have been demonstrated, the subject has not drawn much academic interest as a new subject area of polymer science. This is due largely to the fact that the very unique and advantageous feature (in certain applications) of forming insoluble, infusible polymers has hampered the basic study of the process at the molecular level.

In more recent years, however, the question of whether the concepts of polymers and of polymerization can be applied to plasma-formed materials and to plasma polymerization, respectively, has been reexamined (15). The well-recognized concept of polymerization today is based on the molecular processes by which the size of molecules increases. The arrangement of the atoms that constitute the molecules of a monomer is accomplished during the organic synthesis of the monomer. During the polymerization of a monomer, rearrangement of atoms within the molecule seldom occurs.

In contrast to such molecular processes, polymer formation in plasma has been recognized as an atomic (nonmolecular) process (15). If one adopted such an atomic process to form materials in which the reaction of new covalent bonds between atoms played a predominant role, one could find numerous new processes and resulting materials that would play vitally important roles in modern technologies. The processes recognized as chemical vapor deposition, plasma chemical vapor deposition, ion-assisted vapor deposition, and sputter coating of polymers all fall into this category.

Plasma polymerization was dealt with in the 1960s and 1970s as a method of polymerization. Although some important differences in polymer formation mechanisms and the properties of resultant polymers were recognized, the underlying concept was an extension of the concepts of polymerization and polymers developed with conventional polymers. Consequently, the underlying concept was represented, for example, by the preparation of a thin layer of polystyrene by the plasma polymerization of styrene or the preparation of a thin layer of polytetrafluoroethylene by the plasma polymerization of tetrafluoroethylene. In other words, plasma polymerization was conceived as a new and exotic method of polymerization.

Plasma polymerization today is gaining recognition as an important process for the formation of entirely new kinds of materials. The materials obtained by plasma polymerization are significantly different from conventional polymers and are also different from most inorganic materials. Thus, plasma polymers lie somewhere between organic polymers and inorganic materials. Plasma polymerization should be considered a method of forming such new types of materials rather than a method of preparing conventional polymers. Consequently, the term *plasma polymerization* should not be limited to the formation of organic materials but should cover a wider area that includes metallic or inorganic elements, although the major portion of studies

covered in this volume involve the formation of polymeric materials from organic compounds.

To take full advantage of the new kinds of materials recognized as plasma polymers and of the process by which they are made, it is important to recognize that we are not dealing with conventional polymers and polymerization in the strict sense, although these terms are used. Therefore, considerable effort is spent comparing plasma polymerization with conventional polymerization.

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Scope of Polymer Formation by Plasma Polymerization

2.1 Preferred Form of Plasma Polymers

Historically, polymers formed under plasma conditions were recognized as an insoluble deposit that provided nothing but difficulty in cleaning the apparatus. This undesirable deposit, however, had extremely important characteristics that are sought after in the modern technology of coatings, that is, (1) excellent adhesion to substrate materials and (2) strong resistance to most chemicals.

Awareness of the fact that such material could be utilized as an excellent coating led to the exploitation of the technical method recognized today as plasma polymerization. The undesirable deposit formed in certain electric discharge processes was essentially converted to an excellent coating by controlling the deposition such that it occurred on an appropriate substrate in plasma polymerization. This situation provides an excellent illustration of the uniqueness of the preferred form of plasma polymers.

To appreciate the uniqueness of plasma polymerization, it is useful to compare the steps necessary to obtain a good coating by a conventional coating process and by plasma polymerization. If one wants to coat a certain substrate with a conventional polymer, at least several steps are required: (1) synthesis of a monomer, (2) polymerization of the monomer to form a polymer or intermediate polymer to be further processed in a succeeding step, (3) preparation of coating solution, (4) cleaning and/or conditioning of the substrate surface by application of primer or coupling agent, (5) application of the coating, (6) drying of the coating, and (7) curing of the coating.

In coating by plasma polymerization, in contrast, all these functional steps are replaced by an essentially one-step process starting from a relatively simple gas that often is not considered a monomer for polymerization.

Polymers formed by plasma polymerization aimed at such a coating are in most cases highly branched and highly cross-linked. Such polymers are characteristically formed during plasma polymerization, although low molec-

ular weight materials that are soluble in various solvents and noncohesive powders can also be formed (1).

Chemical reactions that occur under plasma conditions are generally very complex (2-4) and consequently are nonspecific in nature. Such reactions are of merit when special excited states of molecules are required as intermediate states and cannot be achieved, or can be achieved only with great difficulty, by conventional chemical reactions. Thus, plasma polymerization should be recognized as a special means of preparing unique polymers that cannot be made by other methods rather than as a special way of polymerizing monomers.

In this context, the most important forms of plasma polymers are ultrathin films. The characteristics of ultrathin films require special attention. Many bulk properties of a polymer film, such as permeability, electric volume resistivity, and dielectric constant, may be considered material constants. In all characteristic material constants, a thickness factor is included, and therefore these parameters do not change as the thickness of the film varies. This is true for a film as long as its thickness is above a certain critical value, that is, 0.05-0.1 μm , depending on parameters under consideration. As the thickness of the film decreases below the critical value, the constancy of such parameters is no longer observed, probably due to the increased contribution of flaws to the total film, which progressively increases as the thickness of the film decreases.

From the technical point of view, it is very difficult to prepare a flawless film with thickness below the critical value. With certain polymers that have exceptionally good film-forming characteristics, such as cellulose acetate, ultrathin films of such thickness as "monolayer" can be prepared by special techniques such as the spreading of a dilute solution of polymer on a water surface. However, it is extremely difficult to utilize such an ultrathin film in a practical manner, and the technique cannot be applied to any kind of polymer; that is, the method is highly dependent on the film-forming characteristics of polymers.

Thus, the capability of plasma polymerization to form an ultrathin film containing a minimal amount of flaws, if not completely flawless, is unique and is a valuable asset. Many important and useful chemical reactions that occur under plasma conditions but do not yield plasma polymers in this preferred form are not major subjects of this book. Discussions of such reactions can be found in general plasma chemistry texts.

2.2 Plasma-State Polymerization versus Plasma-Induced Polymerization

Plasma, which contains ions, excited molecules, and energetic photons, can be utilized in the general polymerization of organic monomers in a number of ways. In the polymerization of a monomer plasma can be considered a kind of

"radiation" sources. However, in such applications plasma contacts monomer in either the solid or the liquid phase directly, and consequently the transfer of some excited species from the plasma phase to either the liquid or the solid monomer phase takes place. This is a significant difference from ordinary radiation polymerization, in which only energy is transferred to a monomer phase to create reactive species, such as ions or free radical of the monomer.

An important aspect of plasma initiation of monomer liquid or solid is that the formation of polymerization chain-carrying species (e.g., free radicals, cations, or anions) and the propagation of polymer chains take place in the different phases, whereas in most radiation polymerization, these two reactions occur in the same phase.

The principles of plasma-initiated polymerization have been applied to the polymerization of liquid and solid monomers by the insertion of a sealed ampule between a pair of parallel-plate electrodes connected to a 13.56-MHz radio frequency power source (5-9). Polymers with extremely high molecular weight have been formed from some monomers. The formation of polymer film at the interface of monomer and vapor in a sealed ampule was observed when a leak detector (Tesla coil) was used to check for pinholes in the seal (10, 11). In this case, plasma created in the vapor phase in the sealed reaction tube by the Tesla coil initiated the polymerization to yield the film at the interface.

Free radicals formed on the surface of polymers and other solid materials exposed to plasma can be utilized to initiate graft polymerization in a manner that is similar to preirradiation grafting (12, 13). Free radicals formed on polyethylene and polypropylene by plasma were utilized to obtain grafts of vinyl polymers by (1) the direct addition of degassed monomer in a vacuum and (2) the formation of peroxide followed by heating in the presence of degassed monomer.

In all of these examples, polymers are formed by *plasma-induced polymerization*, and the essential chemical reaction is believed to be the conventional molecular polymerization that occurs without the influence of plasma. Although plasma is utilized in these polymerizations, they are distinguished from *plasma-state polymerizations*, which occur only under plasma conditions, that is, vapor phase in the plasma state.

Whereas plasma-state polymerization is limited to the vapor phase and the interface in contact with plasma, plasma-induced polymerization is not limited to liquid- or solid-phase polymerization. When conventional monomers such as vinyl compounds are used in plasma polymerization, both plasma-state and plasma-induced polymerizations can occur simultaneously. The extent to which each mechanism occurs is dependent on the conditions of the plasma polymerization. The details of this aspect are discussed in Chapter 6, dealing with mechanisms of polymer formation.

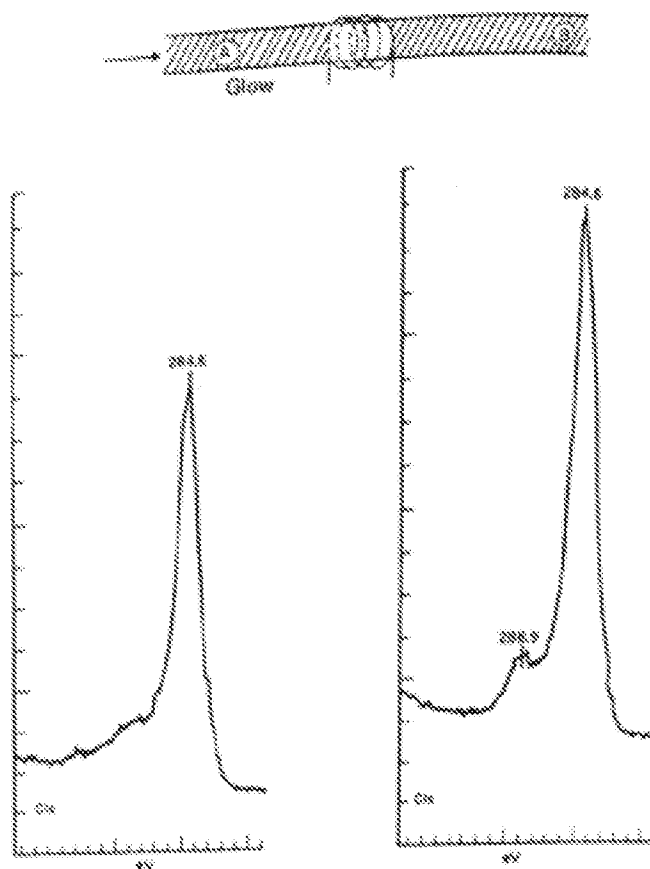


Fig. 6.42 ESCA C_{1s} peaks of glow discharge polymers of tetrafluoroethylene in the same reactor shown in Fig. 6.41, but at the higher discharge power level of 7.7×10^6 J/kg. Adapted from Yasuda (33).

6.8 Atomic (Nonmolecular) Nature of Plasma Polymerization

The plasma polymerization so far discussed is characterized by (1) the extensive fragmentation and/or rearrangement of a structural moiety or atoms in the starting material and (2) simultaneously occurring reactions involving many kinds of chemical species.

These phenomena are seldom found in conventional polymerizations which can be recognized as molecular reactions. In other words, in conventional polymerizations, molecules of monomers are linked together with a minimum alteration of chemical structure of the monomer, and the structure of a polymer can be well predicted from the structure of the monomer. In

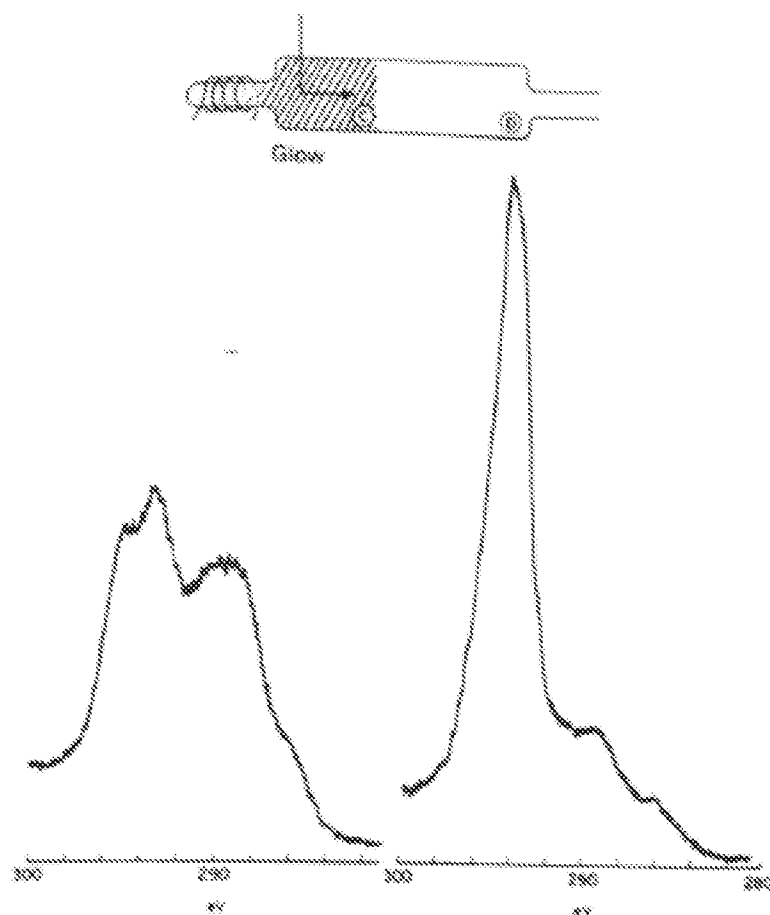


Fig. 6.43 ESCA C_{1s} peaks of glow discharge polymers of tetrafluoroethylene prepared in a reactor shown in the inset: (C) at the end of the glow region; (D) at the end of the tube in the non-glow region. Adapted from Yasuda (33).

contrast, the structure of a polymer formed by plasma polymerization cannot be predicted in this way. Perhaps the only sure prediction one could make would concern the elements constituting the polymer and, to a lesser extent, the elemental ratios.

This situation becomes clearer once we recognize the fact that plasma polymerization is not a regular "molecular polymerization." Such a "non-molecular polymerization" can be expressed by the term *atomic polymerization*. The word *atomic* might be misleading in a general sense; however, insofar as we are discussing the growth mechanisms of polymer formation, perhaps *atomic polymerization* is the most adequate and accurate expression of what is occurring in plasma polymerization.

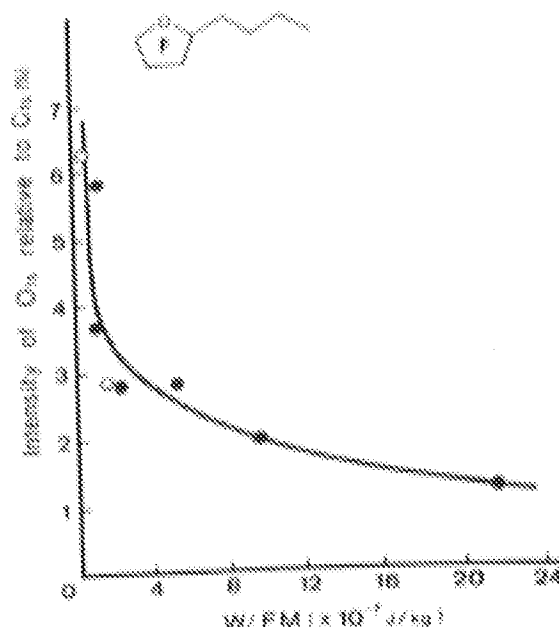


Fig. 6.44 Dependence of oxygen content in the plasma polymer of perfluoro-2-butyltetrahydrofuran on W/FM . Key: $\circ$, reactor B; $\bullet$, reactor C. Adapted from Clark and Abraham (34).

In a molecular polymerization, the arrangement of atoms to form a special molecule of monomer is carried out in the organic synthesis of the monomer, and the rearrangement of atoms and chemical ligands seldom occurs during the process of polymerization. Therefore, the two independent chemical reactions—the synthesis of monomer structure and the polymerization—can be clearly distinguished. In “atomic” polymerization, the structures prepared during monomer synthesis may be largely destroyed; on the other hand, polymers may be formed from simple molecules such as CH_4 and CS_2 that are not the monomers of conventional polymerizations.

“Atomic” polymerization does not imply that the deposition of atoms is a process of plasma polymer formation similar to the formation of a film of metal in the sputter-coating process. It simply means that the building blocks are no longer molecules. After all, one of the most important aspects of plasma polymerization in comparison with other film deposition processes is the formation of covalently bonded materials. In the process of forming covalently bonded materials, conventional (molecular) polymerization uses molecules as the building blocks, but in plasma polymerization this is not the case. In this way, graphitic or diamondlike carbon films can be prepared from benzene by “atomic” polymerization.

The atomic aspect of plasma polymerization is evident in the incorporation of nonpolymerizable gases such as CO , H_2O , and N_2 discussed in Section 6.5. Namely, these gases are incorporated into the polymer structure not as molecules, but as atoms (from a gas). The ionization characteristics of a gas determine its plasma copolymerization characteristics. The important aspect is that active species created by the ionization of a gas do participate in the polymer-forming reactions.

Because of the atomic nature of the growth mechanism of polymer formation, plasma polymerization is highly system dependent. The fragmentation of molecules of a starting material or the rearrangement of molecular structure as visualized by diagnostic data based on the fragmentation products depends on the structure of the starting material and the conditions of plasma polymerization. Therefore, the selection of a monomer for an expected polymer requires a knowledge of the plasma polymerization conditions and of the atomic nature of the process under the conditions. This situation can be illustrated by the plasma polymerization of tetrafluoroethylene versus that of hexafluoroethane in the presence of H_2 gas. The details of this comparison are presented in Chapter 7, where ablation in plasma and the competitive nature of ablation and polymer formation are discussed.

As far as the importance of the atomic nature of plasma polymerization and its significance in the selection of monomer are concerned, the fact that essentially the same polymer can be formed from tetrafluoroethylene and from hexafluoroethane under certain conditions of plasma polymerization should be recognized. There is a significant difference in the costs of these monomers. Under certain conditions, however, the precious structure, $\text{C}\equiv\text{C}$, contributes little to the overall polymer formation mechanism and the results of IR and ESCA indicate that the polymers are almost identical.

The extent of "atomic" polymerization that takes place in a particular set of plasma polymerizations is dependent on parameters specific to the reactor; perhaps the most important factor is the energy input level manifested by W/FM , that is, energy input per mass of monomer given in joules per kilogram. Because of the difficulty of determining the effective flow rate in a reactor, the value of W/FM contains some degree of uncertainty; within a given reactor, however, the value of W/FM can be used as the major parameter of plasma polymerization.

It is important to note that plasma polymerization manifested by polymer deposition rates for various kinds of monomers (carried out in the same reactor) can be reduced to the master relationship (35) shown in Fig. 6.45, where the deposition rate is expressed by polymer deposition rate divided by monomer mass flow rate, and the energy input is expressed by W/FM . In the figure, 16 different monomers from four different groups (each group

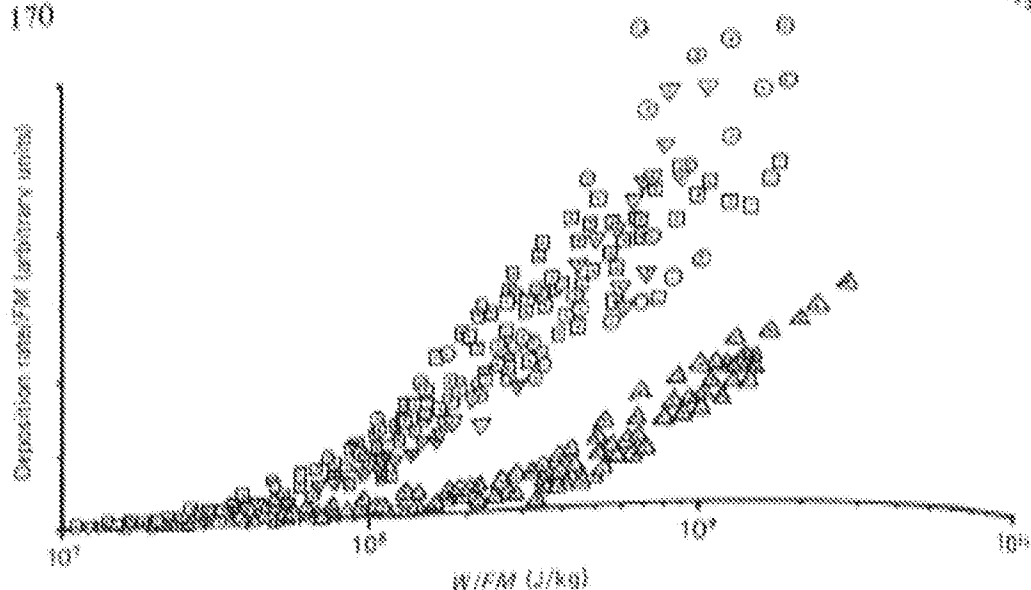


Fig. 6.45 Deposition rate/FM (deposition yield) relationships versus W/FM for four groups of monomers studied. Key: $\circ$, sulfur-containing compounds; $\square$, organosilicones; ∇ , fluorocarbons; $\triangle$, hydrocarbons. Adapted from Garzicki and Yasuda (35).

containing different atoms, e.g., carbon, sulfur, fluorine, and silicon are compared. The deposition rate/mass flow rate represents the value proportional to the conversion yield of monomer to polymer in the system. The following aspects are important, as far as the growth mechanism is concerned, for the contribution of "atomic" polymerization:

1. Despite orders of magnitude differences among deposition rates of monomers at various discharge conditions, the data plotted in this manner show rather small differences among monomers, indicating that all monomers polymerize, by and large, in a similar fashion.
2. There is a clear difference between hydrocarbons and other types of monomers investigated, indicating that the type of atoms contained in the monomer structure plays an important role in plasma polymerization.
3. The differences among monomers within a group, such as hydrocarbons, are greater at a lower energy input level (W/FM), but these differences tend to diminish as the value of W/FM increases, and at very high W/FM regions, all monomers polymerize in an almost identical manner. (This aspect is not clearly seen in Fig. 6.45 due to the compressed scale of the plot.)

The fact that we can make such a master diagram for plasma polymerization has several important implications for the growth mechanism of polymer

formation in plasma. First, if plasma polymerization occurred mainly by true molecular polymerization, which depends on the chemical reactivity, condensability, adsorption, and other characteristics of the monomer, such a master diagram would be beyond the realm of scientific expectation. Second, even in the region where plasma polymerization is considered least atomic or most molecular, the polymer deposition rate is determined largely by the mass of monomer, which indicates that the characteristic rate by which monomer molecules are linked together (to form a polymer) is almost independent of the chemical properties of monomer.

Another "atomic" feature of plasma polymerization is evident from the plasma codeposition of more than one monomer. In conventional molecular polymerization, copolymerization is governed by the monomer reactivity ratio, and a mixture of monomer A and monomer B in a 1:1 ratio does not produce a 1:1 copolymer of A and B, except in the special case of *azeotropic copolymerization*. This is due to the facts that the reactivities of two monomers differ depending on the chemical structures and that polymerization is very specific to the monomer structure and to the chain-carrying species. In contrast, the plasma polymerization of a mixture of two monomers nearly always yields polymers corresponding to azeotropic copolymerization, indicating the absence of specificity of monomers toward plasma polymerization. Because of this, plasma codeposition rather than plasma copolymerization was used to describe the plasma polymerization of more than one monomer when the plasma copolymerization of nonpolymerizable gases was discussed earlier (Section 6.5).

As the extent of the atomic nature of polymerization increases, the extent of fragmentation of the starting material becomes greater, and this straightforward dependence on the mass is less evident. However, in the extreme case of maximum atomic polymerization (in the context discussed in this chapter), the deposition of material is governed by the feed-in rate of atoms that form the backbone or constituent network of material (deposit), and the generalized relationship becomes evident again.

Thus, one cannot discuss plasma polymerization, particularly the polymerization mechanism, in general terms without specifying the domain of plasma polymerization conditions which is discussed in detail in Chapter 9. In conjunction with the major domains of plasma polymerization conditions, we must also pay attention to the location of the polymer deposition. Because there is a very important factor involved in plasma polymerization that cannot be separated from the deposition aspect, detailed discussions of the deposition mechanisms are presented in Chapter 8. In this section, only an important aspect relevant to the growth mechanism is pointed out.

The polymer formation that takes place at or near the electrode surface can be significantly different from that in the rest of the glow. An example of this

aspect can be seen in a comparison of a polymer deposited on the electrode surface and one deposited on a substrate suspended in the plasma phase. ESCA C_{1s} spectra of polymers obtained by the plasma polymerization of tetrafluoroethylene (36) are compared in Fig. 6.46. From the figure, it is quite evident that the polymer formation at the electrode surface and that in the plasma phase could be significantly different. The important point here is that these differences (i.e., the properties of polymers deposited onto substrates at different locations within a reactor and/or onto the electrode surface, etc.) are due to the deposition mechanism rather than the growth mechanism of polymerization. Therefore, it is premature to draw a conclusive picture of plasma polymerization based on a limited case of experimental conditions. Apparently, contradictory findings reported in the literature could often be attributed to this point.

The atomic nature of plasma polymerization can also be seen in a comparison of the properties of plasma polymers of tetrafluoroethylene and of hexafluoroethane. With a double bond in the monomer, $F_2C=CF_2$, the formation of a new $C-C$ bond without the detachment of fluorine (molecular polymerization) is possible, whereas plasma polymerization of hexafluoroethane cannot proceed without the detachment of fluorine atoms

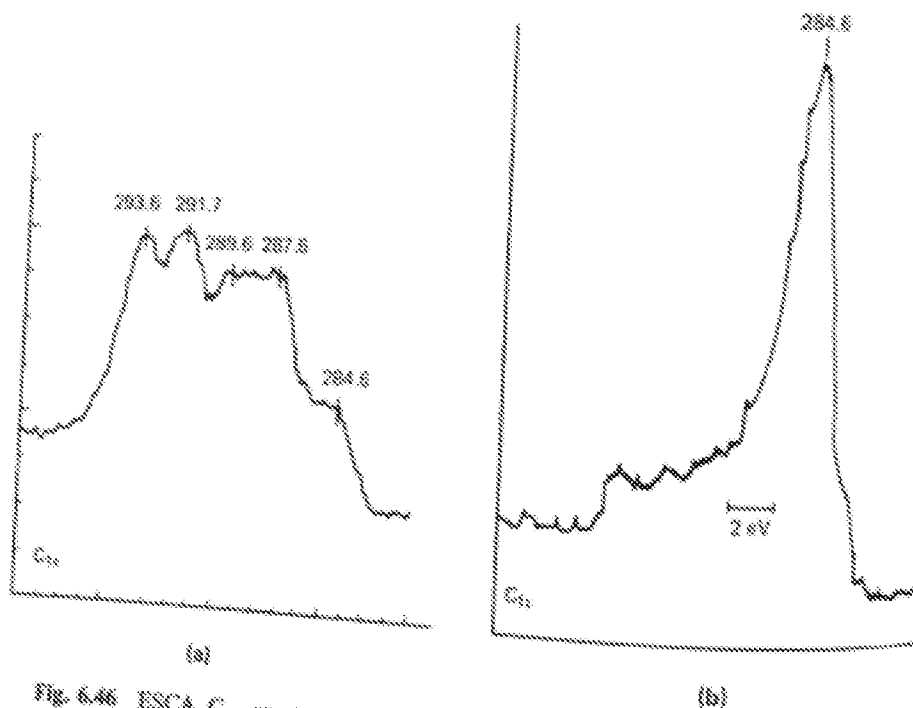


Fig. 6.46 ESCA C_{1s} spectra of plasma polymers of tetrafluoroethylene. (a) Polymer deposited on the electrode surface; (b) polymer deposited on a substrate suspended in plasma. Adapted from Morosoff *et al.* (36).

from the monomer. However, because of simultaneous "atomic" polymerization, which occurs in the plasma polymerization of tetrafluoroethylene and increases with increasing energy input, the contribution of the olefinic double bond is relatively small, as evidenced by the IR spectra of the polymers (37, 38). Infrared and ESCA spectra of the plasma polymers of hexafluoroethane prepared in the presence of H_2 ($H_2/C_2F_6 = 1.0$) are essentially identical to those of the plasma polymer of tetrafluoroethylene polymerized under conditions of low W/FM (see Figs. 6.47 and 6.48). Furthermore, IR and ESCA data for the plasma polymer of tetrafluoroethylene polymerized under conditions of high W/FM , in which "atomic" polymerization dominates, are again virtually identical to those for the plasma polymerization of hexafluoroethane (without H_2).

Acetylene has been considered a main precursor of plasma polymerization by many investigators because of its relatively high rate of polymer deposition and its abundant presence in plasma of hydrocarbons based on plasma diagnostic data. (The precursor concept of the first category discussed in Section 6.6 relies on the intuitive assumption that plasma polymerization proceeds via the chain-growth polymerization of the double or triple bond.) If we recognize the difference in the mass of the starting materials and the

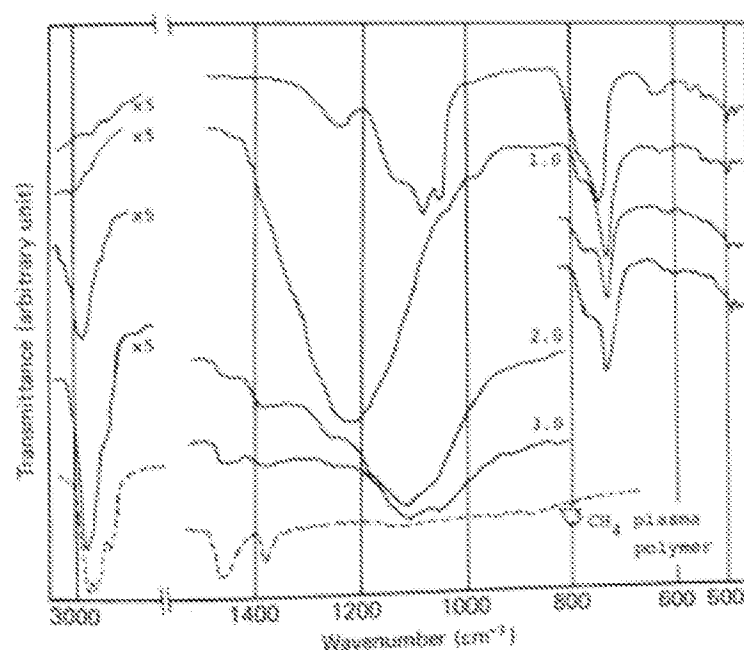


Fig. 6.47 Infrared spectra of various plasma polymers prepared under various H_2/C_2F_6 ratio conditions and also from CH_4 plasma polymerization for reference: 30 W; $F(C_2F_6) = 0.93 \text{ cm}^3/\text{min}$; $H_2/C_2F_6 = 0$. Adapted from Masuoka and Yasuda (37).

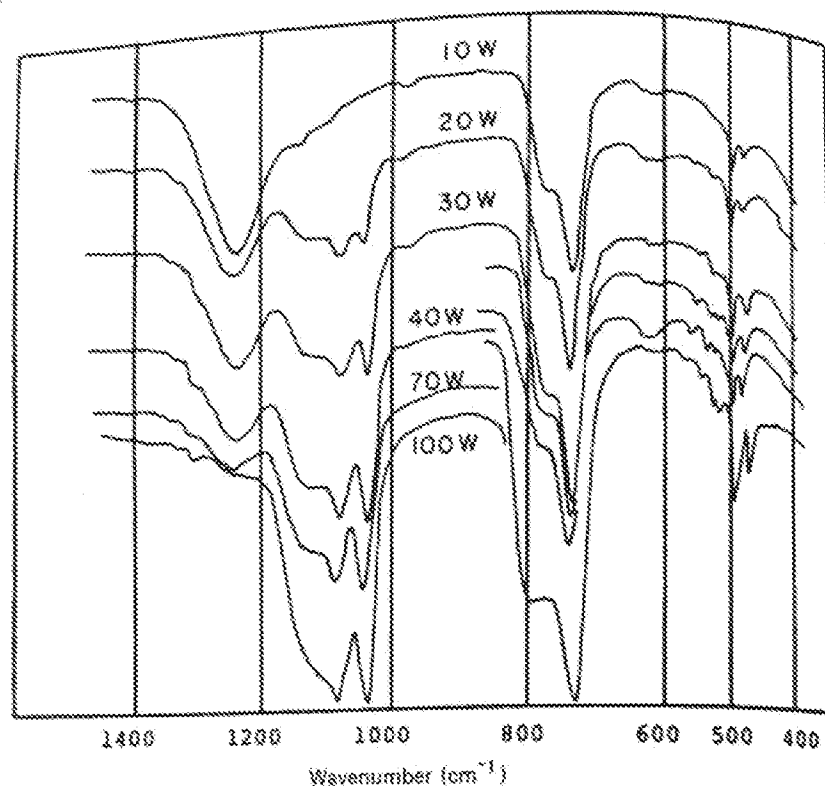


Fig. 6.48 Infrared spectra of plasma-treated sodium chloride powder under various wattage conditions ($F = 0.155 \text{ cm}^2/\text{min}$). Adapted from Masuoka and Yasuda (38).

difference in the mode of polymer collection, however, the specific rates by which polymers deposit are not so different.

Most studies that utilize polymer deposition onto the electrode surface are carried out under conditions of relatively high flow rate and low discharge wattage. Thus, the domain of the plasma polymerization conditions is, in most cases, in the power-deficient region, where the atomic nature of the polymerization is less pronounced. In contrast, Inagaki and Yasuda's data (39) obtained by collecting polymer onto substrates located between electrodes in the monomer-deficient, or the energy-saturated, region obtained by a magnetron glow discharge powered by 10 kHz show very little difference among the deposition rates of polymer from acetylene, ethylene, and methane (Fig. 6.49). If we consider the difference in the mass of the monomers, we come to a different conclusion, namely, that the specific rates by which methane and acetylene polymerize in plasma are very close under these conditions. If one argues that the plasma polymerizations of acetylene in these cases are different, then the entire subject of plasma polymerization becomes meaningless. The growth mechanism with which we are dealing in this chapter is a basic

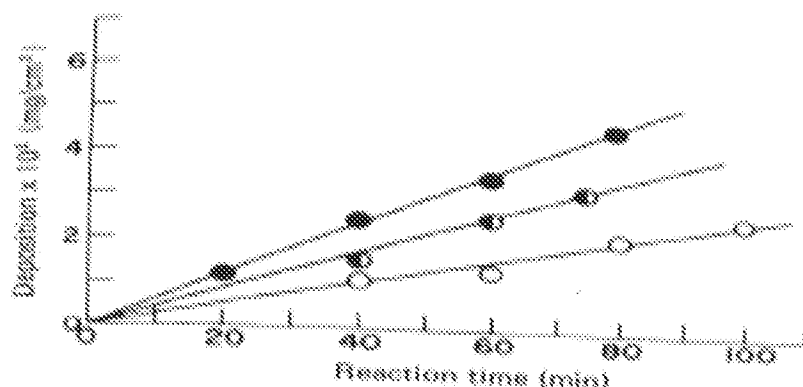


Fig. 6.49 Deposition rate as a function of used gas. Deposition rates (mg/cm²·hr) are as follows: ○ (CH₄), 1.6×10^{-2} ; ◐ (CH₂CH₂), 2.5; ● (CHCH), 3.6. Adapted from Inagaki and Yasuda (39).

mechanism that can be applied to all cases. As discussed in more detail in Chapter 8, this problem cannot be thoroughly understood unless the growth mechanism and the polymer deposition mechanism are separated conceptually.

Thus, "atomic" polymerization, in the context described in this section, is a very important aspect of plasma polymerization. Although the degree to which plasma polymerization is atomic in nature is dependent on the chemical structure of the monomers, the ionization characteristics, and the conditions of plasma polymerization, the complete elimination of "atomic" polymerization from plasma polymerization by manipulating the conditions and the structure of the monomers seems to be nearly impossible. If one could succeed in completely eliminating the contribution of "atomic" polymerization, all advantageous features of plasma polymerization would be lost.

In summary, the most important aspects of the growth mechanism of plasma polymerization are as follows:

1. The chain-growth mechanism does not play a significant role in the vapor depositions of polymers in a vacuum. Addition reactions to the multiple bonds can and would occur in a vacuum; however, the kinetic chain length is too short to be recognized as polymerization in the conventional sense.
2. The major growth mechanism is the rapid step-growth mechanism in which the reactions between the activated species (in contrast to an activated species and a molecule) predominate. Such a reaction might be termed *polyrecombination*, that is, the consecutive recombination of the activated species. The mechanism shown in Fig. 6.1, however, contains reactions that are not polyrecombination.

3. Consequently, any single species or a certain number of dominating species cannot be responsible for the plasma polymerization of a monomer. Furthermore, the nature and number of activated species formed from a monomer are dependent on the conditions of plasma polymerization.

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FAVORED TECH CORPORATION,

Petitioner

v.

P2I LTD.,

Patent Owner

Case No. IPR2020-01198

Patent No. 10,421,876

DECLARATION OF GREGORY N. PARSONS, PH.D.

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I, Gregory N. Parsons, do hereby declare as follows:

I. INTRODUCTION

1. I have been retained on behalf of P2i Ltd. (“P2i”), and its counsel, Fitch Even Tabin & Flannery LLP, as an expert in this proceeding. I am personally knowledgeable about the matters stated herein and am competent to make this declaration.

2. I understand that Favored Tech Corporation (“Favored”) filed a Petition for *Inter Partes* Review regarding certain claims of U.S. Patent No. 10,421,876 (“the ’876 patent”) (Paper 1), which was accompanied by the Declaration of Dr. Karen Gleason (Ex. 1002).

3. I have been asked to investigate and opine on certain issues relating to the ’876 patent (Ex. 1001), and on issues relating Favored Tech’s petition for inter partes review of the ’876 patent. I understand that the Petition asserts the following grounds of unpatentability:

- Ground 1, which alleges obviousness of claims 1–3, 9, and 11–15 based upon Coulson-122 (Ex. 1004), Badyal (Ex. 1005), and Cohen (Ex. 1006);
- Ground 2, which alleges obviousness of claims 1–8 and 10–15 based upon Coulson-122, Badyal, and Holliday (Ex. 1007);
- Ground 3, which alleges obviousness of claims 1–4, 10, and 12–15 based upon Coulson-122, Badyal, and Padiyath (Ex. 1008);

- Ground 4, which alleges obviousness of claims 1–3, 5–8, and 11–15 based upon Coulson-122, Badyal, and Francesch (Ex. 1009); and
- Ground 5, which alleges obviousness of claims 1–3, 5–8, and 12–15 based upon Coulson-122, Badyal, and Tropsch (Ex. 1011).

4. I receive compensation for my time working on this matter, which is billed at an hourly rate of \$595 per hour, plus expenses. I have no financial interest in P2i or in the '876 patent, and my compensation is not dependent on the outcome of this proceeding. The conclusions I present are due to my own judgment.

5. For this declaration, I will first present my technical history and experience relating to plasma processing and thin film coating, and their relation to content within the '876 patent. I will then present my analyses and opinions relating to claims 1–15 of the '876 patent, including my analysis of the Petition and the declaration made by Petitioner's expert, Dr. Karen Gleason.

6. I base this declaration on the information currently available to me. To the extent that additional information becomes available, I reserve the right to continue my investigation and study, which may include reviewing documents and information that may be produced, as well as testimony from any depositions that may be taken.

II. BACKGROUND AND QUALIFICATIONS

Education and Professional Experience

7. My curriculum vitae (CV) is included at the end of this declaration. It includes a detailed record of my educational training, industrial experience, and professional activity and service. It also includes a list of my scientific publications and patents, including many related to the subject matter of this proceeding. I possess the training, education, knowledge, skills, and hands-on experience, to form an expert opinion and provide expert testimony in this matter.

8. Since earning my Ph.D., I have 30 years of professional experience in the fields of Physics and Chemical Engineering, including 3 years industrial experience as a Physics Post-doc at IBM T.J. Watson Research Center, Yorktown Heights NY, and 27 years academic experience as a faculty member in Chemical Engineering at North Carolina (NC) State University. The full 30 years has focused on thin film deposition reactions by plasma and thermally-excited reactions, including deposition of polymeric, inorganic, and combined organic/inorganic materials.

9. I received Bachelor of Arts degree in Physics from the State University of New York, College at Geneseo in 1980. Between 1980 and 1984, I worked as a Physics Research Technician at GTE Laboratories in Waltham, Massachusetts. I

received a Ph.D. in Physics from North Carolina State University in 1990. My Ph.D. research thesis described physical and chemical surface processes during Plasma Enhanced Chemical Vapor Deposition (PECVD) of hydrogenated amorphous silicon, and how those processes influenced the optical and electronic properties of the deposited films for solar cell applications.

10. For my postdoctoral training at IBM TJ Watson Research Center, I continued my study of PECVD reactions and electronic properties of thin films, particularly for applications in thin film transistors used in Active Matrix Liquid Crystal Displays. During my Post-doc, I invented a process for plasma enhanced area-selective deposition of silicon, and received an IBM invention award for my work.

Professional Background

11. My academic career began in 1992 when I joined North Carolina State University as an Assistant Professor of Chemical Engineering, and I have remained employed at NC State since then. I was promoted to Associate Professor with tenure in 1998, and I have been Full Professor from 2002 to the present. I was named as Alcoa Professor from 2009 to 2018, and in 2018 my title became Celanese Acetate Professor, a position I hold now. I also currently hold positions as Associate Faculty in the department of Physics and the department of Materials Science and

Engineering at NC State. Between 2012 and 2014 I also held the position of Visiting RTI Senior Fellow at Research Triangle Institute in Research Triangle Park, North Carolina.

12. As a professor at NC State, I have taken leadership roles in the university and in external professional activities, and received multiple awards for my research, teaching, and service scholarship. In 2001 I co-founded the annual International AVS Atomic Layer Deposition (ALD) Conference which now attracts more than 1,000 participants each year. I was elected Fellow of the American Vacuum Society in 2005, and served from 2011–2013 on the AVS Board of Directors. I am the recipient of an NSF Career Award, the Alcoa Foundation Distinguished Engineering Research Award, and a Semiconductor Research Corporation Invention Award. In 2006, I launched NC State's Nanotechnology Initiative and was Director until 2014. I am also an accomplished classroom teacher, being named to NC State's Academy of Outstanding Teachers in 2009. I am the 2014 recipient of NC State's RJ Reynolds Award, the College of Engineering's highest distinction for faculty research, teaching and service. In 2015 I received the ALD Innovation Award, the highest recognition of accomplishment in the ALD community, and in 2017 I received the NC State Alumni Distinguished Graduate Professorship Award. In 2016 I was selected as part of the inaugural class of the NC

State Research Leadership Academy, and I was elected and served as Academy Chair for 2019-2020 academic year.

13. I am also co-founder and co-owner of VaporPulse Technologies, begun in 2011 as a company providing service for thin film coatings by Atomic Layer Deposition, including materials as well as research and development support.

Research Field and Experience

14. Starting since graduate studies in the late 1980's up to the present, my research has focused on surface and gas-phase chemical mechanisms during thin film formation, modification, and removal by chemical vapor deposition and etching, including reactions during Plasma Enhanced Chemical Vapor Deposition, Atomic Layer Deposition, Plasma-ALD, Molecular Layer Deposition, Chemical Vapor Etching, and Atomic Layer Etching. A key feature of my work addresses means to control or guide fundamental surface reactions to achieve desired surface and film functionality for electronic, catalytic, energy conversion, and other applications.

15. My laboratory at NC State includes more than a dozen thin film deposition and etching reactor systems, all of which were designed and built by myself and my research students and group members. Reactors include small systems for focused surface testing on 2 cm x 2 cm size, up to larger systems capable

of coating on 12 in x 12 in flexible substrates and textiles. Unique expertise in my lab includes surface modification, coating, and analysis of polymers, in particular natural and synthetic polymers in fiber and textile formats. Our group provided the earliest report on ALD coating of textiles, including the effect of coating process and composition on polymer fiber surface energy and wetting. My group is also distinguished by our knowledge and expertise in the area of controlled thin film nucleation, and in the formation of metal-organic framework thin films. Scaling and shrinking of advanced nanoelectronic devices is beginning to rely on controlled nucleation during low-temperature area-selective deposition, where a thin film material of choice is formed only on part of an exposed surface while adjacent parts of the surface remain atomically clean, all while maintaining the reaction temperature to be less than 400°C. A recent study in our group produced more than 30 nm of TiO₂ on SiO₂ without measurable deposition on hydrogen-terminated silicon, a feat which is now a leading bench-mark in the field. Also, our group reported the first study of metal-organic framework thin films on polymer fibers showing rapid catalytic hydrolysis of soman, an active chemical nerve agent.

Scientific Publications

16. As shown in detail on my attached CV, I am the author of more than 270 scientific publications in the fields of physics and chemical engineering, and I

am a named inventor on 5 issued U.S. patents. I am regularly invited to present and discuss my work at scientific symposia and conferences, as well as academic institutions and industrial laboratories across the US and internationally.

17. The '876 patent concerns electronic or electrical devices having a protective coating obtained by exposing the device to a plasma comprising a monomer compound and a crosslinking reagent. I recognize this technology as being well within the sphere of my experience and expertise, and I understand the technology described in the '876 patent fully. I believe my expertise and education in this industry qualifies me to explain this technology and to address the issues of patent validity from the perspective of a person of ordinary skill in the art. I am qualified to submit expert analyses in this proceeding.

III. MATERIALS CONSIDERED

18. In forming my opinions, I have relied on information and evidence identified in this declaration, including the '876 patent, its prosecution history, the declaration of Dr. Karen Gleason, and other references listed as exhibits in Favored Tech's *inter partes* review petition and P2i's preliminary response.

IV. PERSON OF ORDINARY SKILL IN THE ART

19. I have been asked to address the issues from the perspective of a person of ordinary skill in the field relevant to the '876 patent at the time of the

invention, which I am informed is assumed to be June 9, 2015. Dr. Gleason contends that “a POSA at the time of the priority date for the ’876 patent would have had at least a bachelor’s degree in a field such as chemistry, physics, or chemical engineering, as well as at least two years of experience with plasma-polymerization techniques.” (Ex. 1002 ¶ 29.)

20. I agree with Dr. Gleason’s description of one of ordinary skill in the art, except that the use of “at least” with regard to education and experience renders the level of skill unclear. For the purposes of my opinions, I assume that a POSA would have had a bachelor’s degree in chemistry, physics, or chemical engineering and two years of experience with plasma polymerization techniques, with the understanding that “experience with plasma-polymerization techniques” should be interpreted include experience with plasma-enhanced chemical vapor deposition (PECVD) techniques. Dr. Gleason notes that the terms PECVD and plasma polymerization may be used interchangeably. (Ex. 1002 ¶ 12.)

21. I consider myself to have at least the credentials of a person of ordinary skill in the art. As a result of my education, academic experience, and industrial experience, I am familiar with the technology in the field of the ’876 patent and also with the state of that technology in June 9, 2015, the priority date for the ’876 patent. Throughout my career, I have worked with and supervised those of

ordinary skill in the art, and I am capable of addressing the issues from the perspective of such a person.

V. APPLICABLE LEGAL STANDARDS

22. As a technical expert, I am not offering any legal opinions. Rather I am offering technical assessments and opinions. In rendering my analysis, I have been informed by counsel regarding various legal standards for determining patentability. The standards provided by counsel that I was asked to apply in forming the opinions expressed in this declaration are summarized below.

23. The patent claims describe the invention made by the inventors and describe what the patent owner owns and what the owner may prevent others from doing. An independent claim sets forth all the requirements that must be met in order to be covered by that claim. A dependent claim does not itself recite all of the requirements of the claim but refers to another claim and incorporates all of the requirements of the claim to which it refers.

24. A claimed invention is unpatentable if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. In determining whether a claimed invention is obvious, one should consider the scope and content of the prior art, the

level of ordinary skill in the art, the differences between the claimed invention and the prior art, and whether the claimed invention would have been obvious to one of ordinary skill in the art at the time of the invention in light of those differences.

25. I understand a reference may be considered in an obviousness determination only when it is analogous to the claimed invention. A reference is analogous prior art if it is from the same field of endeavor, regardless of the problem addressed, or if the reference is not within the field of the inventor's endeavor, it is reasonably pertinent to the particular problem with which the inventor is involved. To determine the applicable field of endeavor, one must consider explanations of the invention's subject matter in the patent application, including the embodiments, function, and structure of the claimed invention.

26. When evaluating obviousness, one must not consider whether the claimed invention would have been obvious to a layman or to an expert. One must put oneself in the place of a person of ordinary skill at the time the invention was made and consider only what was known before the invention was made. One must avoid the temptation to read into the prior art the teachings of the patent at issue and guard against the use of hindsight. In other words, one should avoid using the challenged patent as a guide through the maze of prior art references, combining the right references in the right way so as to achieve the result of the claims at issue.

27. Obviousness should be considered in light of the problem facing the inventor(s) and the complexity of the alternatives for solving the problem. A patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. It is important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does. One should therefore also consider whether there was a teaching, suggestion or motivation to combine the references. The evaluation of a motivation to combine references allows recourse to logic, judgment, and common sense, but any such motivation to combine references must still avoid the improper application of hindsight. There must be some logical reason apparent from concrete evidence that justifies a combination of the references.

28. It is improper to combine references where the references teach away from their combination. A reference may be said to teach away when a person of ordinary skill would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the inventor. A reference teaches away, for example, if (1) the combination would produce a seemingly inoperative result, or (2) the references leave the impression that the

product would not have the property sought by the inventor or would no longer achieve the intended purpose(s) of the references being modified or combined.

29. I understand that the first step in determining validity is to properly construe the claims. Dr. Gleason has offered interpretations of one term found in the claims at issue. The claim construction principles that I have been asked to follow are summarized below.

30. The claim terms are given their ordinary and customary meaning, as would be understood by a person of ordinary skill in the art at the time of the invention. The person of ordinary skill is considered to read the words used in the patent documents with an understanding of their meaning in the field, and to have knowledge of any special meaning and usage in the field. The ordinary meaning of a claim term is its meaning to the person of ordinary skill after reading the entire patent, including the patent specification. The specification may reveal a special definition given to a claim term by the inventor, which then governs the meaning of the same term in the claims.

31. The claims themselves provide substantial guidance as to the meaning of claim terms, and the context in which a term appears in the claim can be highly instructive to its meaning. Difference among claims can also be a useful guide. For

example, the presence of a dependent claim that adds a particular limitation suggests that the limitation in question is not present in the independent claim.

32. The patent's prosecution history should also be considered, which includes the record of the proceedings before the U.S. Patent and Trademark Office and the prior art cited during the examination of the patent. The prosecution history may inform the meaning of the claim language by demonstrating how the inventor understood the invention and whether the inventor limited the invention in the course of prosecution, making the claim scope narrower than it would otherwise be.

33. My opinions regarding the meaning that a person of ordinary skill in the art would give to certain disputed claim terms are also addressed below.

VI. BACKGROUND TECHNOLOGY

35. Dr. Gleason makes several assertions regarding the background of technology and the knowledge and abilities of persons skilled in the art as of June 9, 2015. In some cases, Dr. Gleason, who is a person of extraordinary skill in the field of plasma polymerization, overstates the knowledge and abilities of a Person of Ordinary Skill (POSA).

36. For example, Dr. Gleason states in paragraph 27 that POSAs "would have known how to adjust plasma composition and reaction conditions to achieve desired properties in the polymer coating." (Ex. 1002 ¶ 27.) In my opinion and based

on my experience, a POSA would have known how to adjust plasma composition and reaction conditions for known and established processes to achieve coatings with known properties, but would not have been able to simply achieve any desired property in a plasma coating, especially if the desired property was not previously known in the art. In the field of plasma polymerization, advancements are often made by highly educated and/or highly experienced researchers. (*See* Ex. 1001; Ex. 1004; Ex. 1005.)

37. A POSA would know that “plasma polymerization is a new material preparation process and is not a kind of polymerization.” (Ex. 2002 at ix.) In particular, “[t]he materials formed by plasma polymerization are vastly different from conventional polymers and constitute a new kind of material.” (*Id.*) A POSA would also know that plasma polymerization is a complex and highly system dependent process, and that changes to the reactor, the parameters used, or the monomers and other gaseous components used in the process can have drastic effects on plasma conditions and the resulting coating. (*Id.* ix–x.; Ex. 2003 (Guimond) p. S447–9, Fig. 3.) The nature of the substrate also affects the properties of the resulting coating, especially with thin film coatings. (Ex. 1004 at 3:9–12.)

38. I agree with Dr. Gleason at paragraph 36 that “[t]he plasma polymerization process creates complex branched and crosslinked molecular chains

due to partial fragmentation of the original monomer molecule” and that the “resulting structural complexity distinguishes plasma polymerization from molecular polymerization techniques in which monomer molecules combine through chemical reactions to form relatively uniform chains or networks of repeating monomer units.” (Ex. 1002 ¶ 36.)

39. As another example of the distinction between conventional polymerization and plasma polymerization, Yasuda is instructive:

To appreciate the uniqueness of plasma polymerization, it is useful to compare the steps necessary to obtain a good coating by a conventional coating process and by plasma polymerization. If one wants to coat a certain substrate with a conventional polymer, at least several steps are required: (1) synthesis of a monomer, (2) polymerization of the monomer to form a polymer or intermediate polymer to be further processed in a succeeding step, (3) preparation of coating solution, (4) cleaning and/or conditioning of the substrate surface by application of primer or coupling agent, (5) application of the coating, (6) drying of the coating, and (7) curing of the coating.

In coating by plasma polymerization, in contrast, all these functional steps are replaced by an essentially one-step process starting from a relatively simple gas that often is not considered a monomer for polymerization.

Polymers formed by plasma polymerization aimed at such a coating are in most cases highly branched and highly cross-linked. Such polymers are characteristically formed during plasma polymerization, although low molecular weight materials that are soluble in various solvents and noncohesive powders can also be formed (1).

Chemical reactions that occur under plasma conditions are generally very complex (2- 4) and consequently are nonspecific in nature. Such reactions are of merit when special excited states of molecules are required as intermediate states and cannot be achieved, or can be achieved only with great difficulty, by conventional chemical reactions. Thus, plasma polymerization should be recognized as a special means of preparing unique polymers that cannot be made by other methods rather than as a special way of polymerizing monomers.

(Ex. 2002 at 4-5.)

40. A POSA would also know that the structural complexity of materials made via plasma polymerization would be more useful for creating nanoscale protective coatings such as barrier layers than coatings made via conventional chemical reactions that have uniform chains. (Ex. 2002 at 5.) Plasma processes also require complex and expensive equipment, and if one could obtain the same materials via conventional polymerization methods, it would easier and more cost effective to use conventional methods. These distinctions between conventional polymerization and plasma polymerization provide reasons why a POSA would not

be motivated to look to references directed to conventional polymerization processes when looking to solve problems related to creating protective coatings using a plasma polymerization process.

41. I disagree with Dr. Gleason's statement in paragraph 53 that "plasma polymerization was known to proceed at least in part according to reaction pathways similar to those that occur following conventional activation techniques (like free-radical, solution-phase, or heat-based polymerization)." (Ex. 1002 ¶ 53.) A POSA would expect other reaction pathways to also occur. Further, a POSA would not reasonably have expected to predict the structure or properties of a plasma polymerized coating based on the use a particular crosslinker in a conventional polymerization process. Yasuda explains:

The plasma polymerization so far discussed is characterized by (1) the extensive fragmentation and/or rearrangement of a structural moiety or atoms in the starting material and (2) simultaneously occurring reactions involving many kinds of chemical species.

These phenomena are seldom found in conventional polymerizations, which can be recognized as molecular reactions. In other words, in conventional polymerizations, molecules of monomers are linked together with a minimum alteration of chemical structure of the monomer and the structure of a polymer can be well predicted from the structure of the monomer. In contrast, the structure of a polymer

formed by plasma polymerization cannot be predicted in this way. Perhaps the only sure prediction one could make would concern the elements constituting the polymer and, to a lesser extent, the elemental ratios.

This situation becomes clearer once we recognize the fact that plasma polymerization is not a regular "molecular polymerization."

(Ex. 2002 at 166–67.)

42. I disagree with Dr. Gleason's statement in paragraph 53 that "POSAs understood and expected that the same types of crosslinking reagents used for conventional polymerization would also work in plasma polymerization reactions." First, she doesn't explain what it means to "work". (Ex. 1002 ¶ 53.) Second, the references she cites to do not support her conclusion. For example, Badyal (Ex. 1005) does not suggest to a POSA that any crosslinker known in the polymer art would be effective to improve the durability of a plasma polymerized coating, as discussed below in my summary of Badyal. In addition, the Tarducci article (Ex. 2023 at 8725) is directed to pulsed plasma polymerization using only a single monomer at a time and does not discuss adding a crosslinker to a monomer.

43. As discussed above, coatings formed by plasma polymerization are not analogous to those formed in conventional polymerization processes. (Ex. 2002 at 2–3, 4–5, 166–7.) Combining a crosslinking reagent to another monomer in a

conventional polymerization process will lead to a different result than combining the same compounds in a plasma polymerization process. (Ex. 2002 at 166–7, 171.) Yasuda explains the difference between polymerizing two monomers in a conventional polymerization process vs. a polymerization process:

Another "atomic" feature of plasma polymerization is evident from the plasma codeposition of more than one monomer. In conventional molecular polymerization, copolymerization is governed by the monomer reactivity ratio, and a mixture of monomer A and monomer B in a 1: 1 ratio does not produce a 1: 1 copolymer of A and B, except in the special case of *azeotropic copolymerization*. This is due to the facts that the reactivities of two monomers differ depending on the chemical structures and that polymerization is very specific to the monomer structure and to the chain-carrying species. In contrast, the plasma polymerization of a mixture of two monomers nearly always yields polymers corresponding to azeotropic copolymerization, indicating the absence of specificity of monomers toward plasma polymerization.

(Ex. 2002 at 171.)

44. Further, plasma polymerization is inherently unpredictable and making changes to a process, such as by adding an additional compound, can have drastic effects. (Ex. 2003 at S4448–9, describing vastly different deposition results when NH_3 added to C_2H_4 in different ratios.) Yasuda explains:

Because of the atomic nature of the growth mechanism of polymer formation, plasma polymerization is highly system dependent. The fragmentation of molecules of a starting material or the rearrangement of molecular structure as visualized by diagnostic data based on the fragmentation products depends on the structure of the starting material and the conditions of plasma polymerization. Therefore, the selection of a monomer for an expected polymer requires a knowledge of the plasma polymerization conditions and of the atomic nature of the process under the conditions. This situation can be illustrated by the plasma polymerization of tetrafluoroethylene versus that of hexafluoroethane in the presence of H₂ gas. The details of this comparison are presented in Chapter 7, where ablation in plasma and the competitive nature of ablation and polymer formation are discussed.

(Ex. 2002 at 169) (emphasis added.)

VII. OVERVIEW OF THE '876 PATENT

45. I understand that the '876 patent is titled "Coatings." I understand the '876 patent arose from an international patent application filed December 15, 2016, which in turn claims priority back to a European patent application filed June 9, 2015.

46. The '876 patent states that the invention particularly relates to providing an electronic or electrical device or component thereof having a cross-linked polymeric coating obtained by exposing the device to a plasma comprising a

monomer compound and a crosslinking reagent. (Ex. 1001 at Abstract.) The '876 patent claims an electronic or electrical device (or electronic or electrical component thereof) having a protective coating obtained by exposing the device to a plasma comprising a particular monomer compound and crosslinking reagent. The '876 patent describes the difficulties in obtaining plasma-derived protective coatings on electronic devices, such as mobile phones. (Ex. 1001 at 1:20–2:6.) In particular, the desired coatings should have a high water contact angle (i.e., be highly hydrophobic) but also stable, tack-free, and resistant to smearing. (*Id.* at 1:20–2:6; 4:26–35.) The inventors described that when using the monomer 1H, 1H, 2H, 2H-perfluorooctyl acrylate (PFAC6) to form a plasma polymerized coating, applying lower power resulted in a more hydrophobic coating, but found the coating was unstable in the presence of water and was tacky and easily smeared. (*Id.* at 1:34–56.) They also found that applying higher powers created coatings that were more crosslinked and resistant to smearing but decreased the coating's hydrophobicity. (*Id.* at 1:47–67, 16:4–10, FIGS. 1 and 2.) Accordingly, the inventors recognized the process conditions required for producing tack and smudge-free protective coatings for electronic devices were limited and lacked sufficient hydrophobicity. (*Id.* at 2:1–6.)

47. The inventors discovered that they could obtain improved protective nanoscale coatings and also increase the range of suitable plasma processing conditions by adding particular crosslinking molecules to the monomer introduced during the plasma polymerization process. (*Id.* at 2:49–55.) The cross-linked copolymer protective coating could be obtained by low energy pulsed plasma processing and exhibited improved hydrophobicity while remaining tack and smudge-free. (*Id.* at 2:56–64, 16:58–17:19, compare FIGS. 2 and 4.) The '876 patent states that these properties make the coating “suitable for the coating of electronic devices to prevent the ingress of water-based liquids” to protect such devices from accidental damage. (*Id.* at 2:56–64.)

48. The '876 patent states that the coating formed according to the invention is a protective layer, in that it prevents damage by contact with water or other liquids, and may provide protective functionality by forming a liquid repellent layer and/or a physical barrier layer. (*Id.* at 3:8–11.) The '876 patent explains that a coating with a water contact angle (WCA) of at least 90 degrees is typically a water repellent layer. (*Id.* at 4:26–30.) The inventive coatings, particularly when thicker than 50 nm, act as physical barrier coatings, which provide a barrier to mass and electron transport and restrict diffusion of water, oxygen, and ions. (*Id.* at 3:3–11.) Accordingly, the coatings are particularly advantageous for protecting electronic

devices like mobile phones, including the internal electronic components thereof. (*Id.* at 1:5–13, 14:30–58.) The '876 patent explains that these barrier coatings are electrically insulating while remaining sufficiently compliant or alterable to allow electrical connections to be made to the device without needing to remove the coating, e.g., to allow the device to be connected to a charging cable. (*Id.* at 3:41–54.)

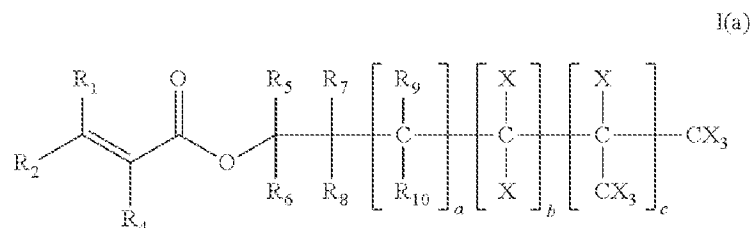
49. The '876 patent describes that electrical devices having the barrier coating will typically have an electrical resistance of at least 1×10^7 Ohms and allow the coated device to be submerged in water of up to 1m for 30 minutes while powered on, which is sufficient to pass the IPX7 test. (*Id.* at 3:55–4:6.) The inventors also discovered that the barrier coatings were significantly more electrically resistant than the coating formed without the crosslinking reagent. (*Id.* at 16:46–54, FIG. 5, 18:10–23.) Example 5 shows an increase in resistance of the coating from 2.1×10^7 to 9.2×10^9 Ohms when 10% DVA crosslinker was added to PFAC6 monomer. (*Id.* at 18:10–23.)

50. The '876 patent specifies a variety of monomers and crosslinkers that may be used. (*Id.* at 4:36–13:6.) Claim 1 is recited below:

An electronic or electrical device or electronic or electrical component thereof comprising a protective cross-linked polymeric coating on a surface of said device or component;

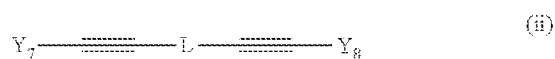
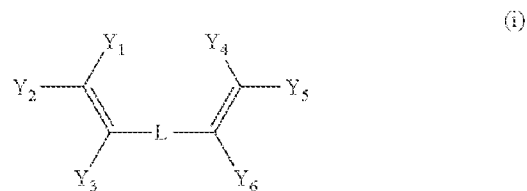
wherein the protective cross-linked polymeric coating is obtained by exposing said device or component to a plasma comprising a monomer compound and a crosslinking reagent for a period of time sufficient to allow formation of the protective cross-linked polymeric coating on a surface thereof,

wherein the monomer compound is a compound of formula I(a):



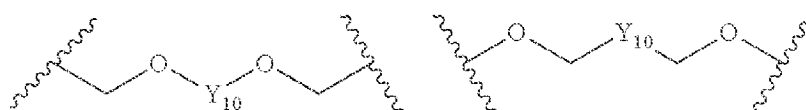
wherein each of R₁, R₂, R₄ and R₅ to R₁₀ is independently selected from hydrogen or an optionally substituted C₁-C₆ branched or straight chain alkyl group; each X is independently hydrogen or halogen; a is from 0-10; b is from 3 to 7; and c is 0 or 1;

and wherein the crosslinking reagent comprises two or more unsaturated bonds attached by means of one or more linker moieties and has a boiling point of less than 500° C. at standard pressure, the crosslinking reagent having one of the following structures:



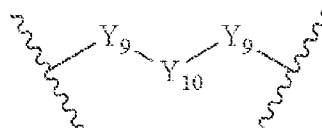
where Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 , Y_7 and Y_8 are each independently selected from hydrogen, optionally substituted cyclic, branched or straight chain C_1 - C_6 alkyl or aryl; and L is a linker moiety;

wherein for compound (i) L is of formula A having one of the following structures:



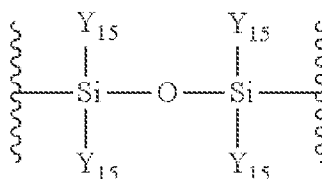
and Y_{10} is selected from optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene and a siloxane group;

or wherein for compound (i) L is of formula B having the following formula:



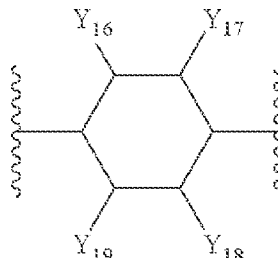
where each Y_9 is independently selected from, a bond, $—O—$, $—O—C(O)—$, $—C(O)—O—$, $—Y_{11}—O—C(O)—$, $—C(O)—O—Y_{11}—$, $—OY_{11}—$, and $—Y_{11}O—$, where Y_{11} is an optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene; and

wherein Y_{10} has the following formula:



and each Y_{15} is independently selected from optionally substituted branched or straight chain C_1 - C_6 alkyl;

or wherein Y_{10} has the following formula:



and Y₁₆ to Y₁₉ are each independently selected from H and optionally substituted branched or straight chain C₁-C₈ alkyl or alkenyl.

51. As is evident from the patent specification and discussion above, the '876 patent's field of endeavor relates to plasma polymerized protective coatings. Claim 1 requires an electronic device having a protective coating, obtained by exposing the device to a plasma. (*Id.* at 18:26–36.) The Field of Invention in the '876 patent states “the present invention relates to protective coatings for electronic or electrical devices and components thereof, and methods for forming such coatings.” (*Id.* at 1:5–13.) Each example in the '876 patent similarly involves plasma polymerized protective coatings for electronic devices. (*Id.* at 15:40–16:54, 16:58–7:19.)

52. The '876 patent describes the problems that the inventors were addressing: obtaining protective coatings that did not smear, were tack free, but also had sufficient protective qualities suitable for electronic devices, including hydrophobicity and electrical resistance. (*Id.* at 1:15–2:6.) The inventors of the '876 patent were confronted with problems specific to plasma polymerization and

protection of electronic devices, and in particular with regard to plasma deposited coatings formed by PFAC8 and PFAC6. The problems described in the Background relate to the impact of power of the *plasma* on the nature of the polymer—a problem specific to plasma polymerization. (*Id.* at 1:20–21.) The power applied during plasma processing can affect the amount of fragmentation the monomer, impacting properties of the coating such as water contact angle and stability (e.g. resistance to smearing). (*Id.* at 1:20–33, 57–67.) After describing these problems, the '876 patent explicitly states “it is an aim to solve one or more of the above-mentioned problems with the prior art coatings.” (*Id.* at 2:5–7.) Accordingly, the inventors in the '876 patent expressly described the particular problems they were attempting to solve, all which related to plasma polymerized protective coatings for electronic devices.

53. From my review of the asserted prior art, it is my opinion that the claimed combination of monomers and crosslinking reagents were not previously known nor used in a plasma process to obtain a protective coating for an electronic device. It is also my opinion that claim 1 would not have been obvious to a person of ordinary skill in view of the asserted references.

VIII. CLAIM CONSTRUCTION

54. I understand that Dr. Gleason states that a POSA would have understood the term “halogen” in claim 1 to mean at least fluorine, chlorine, and

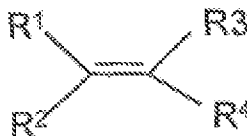
bromine. I agree.

IX. SUMMARY OF THE ASSERTED REFERENCES

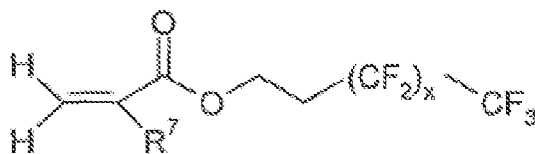
A. Coulson-122

55. Coulson-122 discloses an electronic device having a polymeric coating formed by exposing the device to a pulsed plasma composition that includes a particular formula of monomers. (Ex. 1004 at 3:20–34, claim 1.) Coulson-122 notes that plasma polymers had previously been used to coat fabric substrates, and describes the inventor's discovery that by utilizing a specific type of monomer under particular deposition conditions, a highly liquid repellent nano-coating could be deposited on an electronic device without affecting the operation of the device. (*Id.* at 2:32–3:18.)

56. Coulson-122 discloses that the monomer may have the following general structure:



(*Id.* at 3:20–25.) In a particular example, Coulson-122 discloses a monomer having the following structure:



where R⁷ is hydrogen, C₁₋₁₀ alkyl, or C₁₋₁₀ haloalkyl and x is an integer from 1 to 9. (*Id.* at 12:13–21). When R⁷ is hydrogen and x is 7, the monomer is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate. (*Id.* at 12:21–22, claims 11 and 28.)

57. Coulson-122 teaches a polymeric coating is formed on an electronic device by exposing the device to a pulsed plasma including the disclosed monomer. (*Id.* at 3:20–25.) The device is exposed to the pulsed plasma for a sufficient period of time to allow a protective polymeric layer to form on the surface of the device. (*Id.* at 3:20–34, 4:1–3.) With regards to plasma polymerization, Coulson-122 describes, and a POSA would know, that “[t]he properties of the resultant coating can depend upon the nature of the substrate as well as the nature of the monomer used and conditions under which it is deposited.” (*Id.* at 3:9–12.)

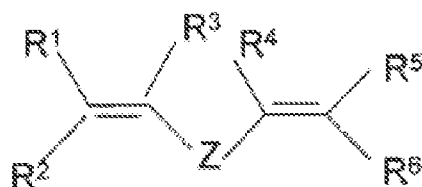
58. Coulson-122 does not disclose use of a more than a single monomer at a time, nor does Coulson disclose using a crosslinking reagent alone or in combination with the disclosed monomers in the pulsed plasma. (*Id.* at 7:19–24.)

B. Badyal

59. Badyal describes a method of coating a surface, such as a fabric, with a

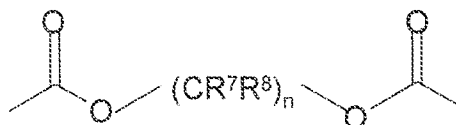
polymer layer which includes exposing the surface to a plasma comprising one or more organic monomeric compounds, at least one of which comprises two double bonds. (Ex. 1005 at 4:4–8.) The method forms a layer of cross-linked polymer on the surface of the fabric to form a water- and oil- repellant coating. (*Id.* at 1:3–5, 4:8–9, 6:10–12, 9:18–19.) Badyal states that “any solid substrate, such as fabric, metal, glass, ceramics, paper or polymers” may be coated, but Badyal focuses particular on fabric substrates. (*Id.* at Abstract, 1:14–19, 1:25–2:8, 2:31–3:2, 4:26–29, 9:28–34, 10:1–6, 11:22–24, claim 14.) Badyal discloses that such coatings applied to fabrics have sufficient durability to withstand washing. (*Id.* at 4:24–29.) Badyal discloses that durability means that the coating is sufficiently bonded to the fabric to withstand washing without being washed off. (*Id.* at 1:25–34.) Badyal never says that his coatings are protective. Further, just because a coating is durable on a fabric does not mean that the coating would be protective for an electronic device, or sufficient to withstand accidental dropping of an electronic device in water. Accordingly, a POSA reading Badyal would not expect that Badyal’s coatings would be suitable for electronic devices. Nor would a POSA understand from Badyal that plasma polymerization of a crosslinker in combination with PFAC8/PFMAC8 would improve the characteristics of the resulting coating applied to an electronic device.

60. Badyal discloses that a suitable crosslinking compound may be combined with an organic monomer in a plasma to improve the durability of a coating. (4:16-29.) Badyal describes that suitable crosslinking compounds have the following general formula (I):



where Z is a particular bridging group. (*Id.* at 5:1–5.) Badyal then describes in particular suitable substituents for R1-R6 and the bridging group Z. (*Id.* at 5:3–6:20.) Badyal describes that example of suitable bridging groups Z “are those known in the polymer art” and then goes on to describe that they include optionally substituted alkyl groups which may be interposed with oxygen atoms, and also include perhaloalkyl groups and perfluoroalkyl groups. Badyal then describes preferred examples as shown below:

In a particularly preferred embodiment, the bridging group Z includes one or more acyloxy or ester groups. In particular, the bridging group of formula Z is a group of sub- formula (II)

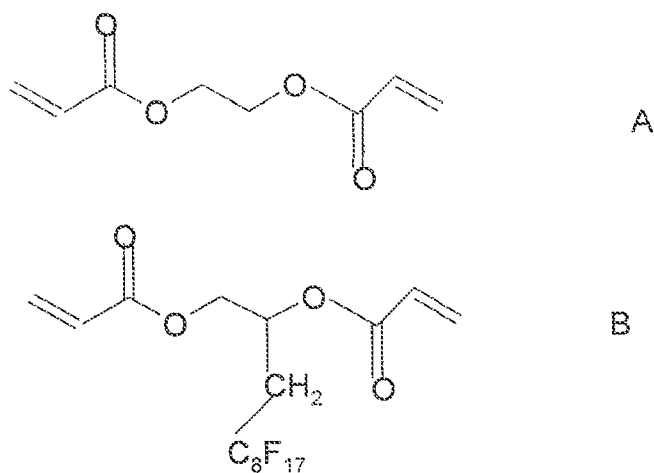


where n is an integer of from 1 to 10, suitably from 1 to 3, each R^7 and R^8 is independently selected from hydrogen, alkyl or haloalkyl.

Suitably R^1 , R^2 , R^3 , R^4 , R^5 , and R^6 are haloalkyl such as fluoroalkyl, or hydrogen. In particular they are all hydrogen.

Suitably the compound of formula (I) contains at least one haloalkyl group, preferably a perhaloalkyl group. This allows the formation oil repellent as well as water repellent coatings. This group is suitably located as a group R^7 or R^8 within the bridging group Z .

Thus particular examples of compounds of formula (I) include the following:



(*Id.* at 5:18–6:20.)

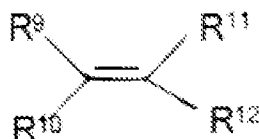
61. A POSA reading Badyal in its entirety would understand its disclosure of the crosslinking formula and bridging group Z would not be so broad as to include any known compound in the polymer art. Instead, Badyal's disclosure is focused on plasma polymerization for forming oil and water repellent coatings. Badyal teaches,

and a POSA would understand, that “[t]he success or otherwise of plasma polymerization depends upon a number of factors, including the nature of the organic compound.” (*Id.* at 2:26–28.) Badyal at first broadly discloses that the crosslinking compound used should have more than one double carbon-carbon bond, but then limits this broad description by stating that “suitable compounds with more than one carbon-carbon double bond . . . used in the plasma are suitably those which will yield cross-linked polymers having oil or water repellent properties.” (*Id.* at 4:4–21.) Accordingly, a POSA would understand that Badyal discloses that the suitable crosslinking compounds must be capable of forming a plasma-polymerized coating having oil or water repellent properties. Badyal then provides specific examples of suitable formulas and two particularly preferred compounds, as discussed directly above, which further suggests to a POSA a much narrower range of suitable reagents.

62. The particular bridging groups Z disclosed in Badyal, however, do not disclose the linker moiety “L” claimed in claim 1 of the ’876 patent. Of the only two specific examples of compounds A and B which satisfy formula (I), neither include the linker moiety claimed in the ’876 patent.

63. Badyal describes that other monomeric compounds that may be used in combination with the disclosed crosslinking compounds to form the coating,

including compounds having the following general formula:



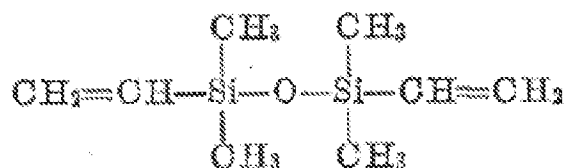
(*Id.* at 7:17–32.) Badyal describes that in one embodiment, the other monomeric compound may have the following formula:



where R^{13} is an alkyl or haloalkyl group and R^{15} is a hydrogen or C_{1-6} alkyl, such as methyl. (*Id.* at 7:26–27, 9:10–16.) Badyal describes that R^{13} is preferably a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is an integer. (*Id.* at 8:15–18.) When R^{13} is a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is 8 and R^{15} is a hydrogen, the monomeric compound is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate (PFAC8). None of the secondary references (Cohen, Holliday, Padiyath, Francesch, or Tropsch) describe using a crosslinker with PFAC8.

C. Cohen

64. Cohen describes a monomer divinyltetramethyldisiloxane (DVTMDS or disiloxane) created by the inventor and polymerization products produced therewith. (Ex. 1006 at 1:15–20.) Cohen describes DVTMDS as having the formula:



(*Id.* at 1:27–30.)

65. Cohen does not disclose plasma polymerization processes to form protective coatings for electronic devices. It discloses how to formulate DVTMDS, as well as conventional polymerization processes to form copolymers using DVTMDS (*Id.* at 1:34–44, 2:70–3:50.) Cohen explains:

For example, the disiloxane with the other copolymerizable material may be dissolved in a suitable inert solvent, for example, an aromatic hydrocarbon solvent (such as benzene, toluene, xylene, etc.) and polymerization of the mixture effected. Another method which may be employed in preparing copolymers the instant claimed invention includes the preparation of an intimate mixture of the monomeric materials by preparing suspensions or emulsions of the disiloxane and the copolymerizable material in a liquid medium as, for example, water.

(*Id.* at 34–44.) As this passage reflects, Cohen discloses effecting polymerization in an inert solvent or in an emulsion.

66. Cohen discloses that copolymers made using DVTMDS may be used as a dielectric material in a capacitor, a cable or electrical coil impregnant, and a filling compound in potheads and cable joints. (*Id.* at 5:1–21.) Cohen does not

describe the use of DVTMDS with the specific monomers recited in claim 1 of the '876 patent.

67. In my opinion, a POSA would not look to Cohen to improve a plasma-formed protective coating for an electronic device. Cohen is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Cohen also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

D. Holliday

68. Holliday relates to curable insulating compositions for “dip coating electrical connectors and other conductors.” (Ex. 1007 at 1:12–15, 1:23–25, 2:16–21, 2:60–64.) Holliday describes that the compositions are particularly suitable for insulating underground secondary bus connectors used in the utility industry. (*Id.* 1:52–2:35.) Holliday describes various disadvantages with previously known molded, pre-shaped rubber insulating boots and sleeves, plastisol coatings, and thermosetting resin coatings for electrical connectors. (*Id.* at 1:26–51.) For example, molded insulations were expensive and lacked versatility, and plastisol coatings lacked sufficient electrical and heat distortion properties. (*Id.* at 1:63–2:16.) Holliday discloses a curable composition of polyolefin, polyvinylchloride and a

reactive allylic or vinylic monomer. (*Id.* at 2:39–42.) The composition is created by “forming an intimate admixture of the polymeric components of the composition and the reactive monomer” along with an optional curing agent, or is optionally cured using irradiation techniques. (*Id.* at 2:47–70.)

69. Holliday discloses that crosslinking allylic or vinylic monomers are employed in its dip coating compositions. (*Id.* at 3:21–54.) Among a list of approximately 52 possible monomers, Holliday includes diallyl-1,4,-cyclohexanedicarboxylate (DCHD) a suitable allylic monomer and 1,4-divinyl-oxybutane (also known as 1,4,-butanediol divinyl ether or BDVE) as a suitable vinylic monomer. (*Id.* at 3:34–35; 3:52–53.)

70. Holliday does not relate to plasma polymerization processes. Holliday also is unrelated to forming plasma derived protective coatings for electronic devices or otherwise. Holliday also does not describe the use of DCHD or BDVE with the specific monomers recited in claim 1 of the '876 patent.

71. In my opinion, a POSA would not look to Holliday to improve a plasma-formed protective coating for an electronic device. Holliday is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Holliday also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for

electronic devices.

E. Padiyath

72. Padiyath is entitled “Moisture Barrier Coatings” and relates to multi-layer barrier assemblies for the protection of a moisture or oxygen sensitive article, and particularly organic light emitting diode devices (OLEDs). (Ex. 1008 ¶¶ 2, 5.) The barrier assemblies include alternating diamond-like glass (DLG) layers and polymer layers, which may be crosslinked. (*Id.* ¶¶ 25, 30, 52.) Padiyath discloses two lists of possibilities for preferred and alternative monomers that can be used to form its polymer layers. (*Id.* ¶¶ 52, 54.) One of the monomers in the list of alternative monomers is cyclohexane dimethanol diacrylate esters. (*Id.* ¶ 54.)

73. Padiyath discloses forming polymer layers used in a multi-layer stack of the barrier assemblies by “crosslinking the layer to form the polymer in situ, e.g., by flash evaporation and vapor deposition of a radiation crosslinkable monomer, followed by crosslinking using, for example, an electron beam apparatus, UV light source, electrical discharge apparatus or other suitable device.” (*Id.* ¶¶ 52, 61.) Padiyath states that plasma polymerization may be employed “if it will provide a polymeric layer having a glassy state at an elevated temperature, with a glass transition temperature greater than or equal to that of HSPET.” However, Padiyath describes that “[m]ost preferably, the polymer layers are formed by flash

evaporation and vapor depositing *followed by* crosslinking in situ . . .” (*Id.* ¶ 61) (emphasis added.)

74. Padiyath fails to disclose use of the cyclohexane dimethanol diacrylate esters with the specific monomers claimed in ’876 patent and fails to suggest that the dimethanol diacrylate esters should be applied via a plasma in combination with another monomer. Accordingly, in my opinion, a POSA would not look to Padiyath to improve a plasma-formed protective coating for an electronic device.

F. Francesch

75. Francesch is an article entitled “Fabrication of Bioactive Surfaces by Plasma Polymerization Techniques Using a Novel Acrylate-Derived Monomer.” Francesch discloses the fabrication of bioactive surfaces using a new monomer pentafluorophenyl methacrylate (PFM) synthesized by the authors. (Ex. 1009 at 605.) The resulting coatings “leave the labile pentafluorophenyl group on the surface, enabling a rapid reaction with an amino-terminated biotin ligand and allowing layer-by-layer self-assembly of biotin-streptavidin.” (*Id.*)

76. Francesch describes that the novel PFM monomer can be deposited alone or can be copolymerized with 1,7-octadiene or 1,4-butanediol divinyl ether (BDVE) as crosslinkers to form the bioactive surface. (*Id.* at 606.) Such bioactive surfaces have application in tissue engineering and therefore are unrelated to

protective coatings for electronic devices. (*Id.* at 605, 610–11.) Francesch does not disclose or suggest the use of BDVE with the specific monomers claimed in the '876 patent.

77. In my opinion, a POSA would not look to Francesch to improve a protective coating for an electronic device. Francesch is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Francesch also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

G. Tropsch

78. Tropsch is entitled “Preparation of Polymers Comprising Peroxycarboxyl Groups” and as the title suggests, relates generally to processes for preparing polymers comprising peroxycarboxyl groups. (Ex. 1011 at 1:4–7.) Tropsch discloses it is an object of the invention to “provide a process for preparing polymers comprising peroxycarboxyl groups by reacting polymers comprising monoolefinically unsaturated dicarboxylic anhydride basic building blocks with hydrogen peroxide . . .” (*Id.* at 1:26–33.) Tropsch discloses that the polymers prepared according to the invention can be used in a wide range of applications, including as bleaches, disinfectants, and cleaners, and recites a variety of product

applications including acne remedies, tooth bleaches, cuticle softeners, and vaginal suppositories. (*Id.* 5:60–6:21.) Tropsch describes that the polymers can be crosslinked using “any suitable crosslinker[]” and describes numerous classes and dozens of specific examples, including 1,6-hexanediol divinyl ether. (*Id.* at 3:47–54, 4:34–39.)

79. Tropsch is unrelated to plasma polymerization and protective coatings formed via a plasma. Tropsch also does not describe that 1,6-hexanediol divinyl ether could be employed in a plasma polymerization process, is suitable for forming coatings, or could be used with the specific monomer structures specified in claim 1 of the '876 patent. In my opinion, a POSA would not look to Tropsch to improve a protective coating for an electronic device. Tropsch is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Tropsch also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

X. CLAIMS 1–15 ARE NOT OBVIOUS BASED ON THE COMBINATION OF COULSON-122, BADYAL, AND EACH OF COHEN, HOLLIDAY, PADIYATH, FRANCESCHI, AND TROPSCH

80. I disagree with Dr. Gleason’s analysis and conclusion in paragraphs 114–214 (Ex. 1002 ¶¶ 114–214) that the subject matter of the challenged claims of

the '876 patent would have been obvious to a POSA based on the disclosures of Coulson-122, Badyal, Cohen, Holliday, Padiyath, Francesch, and Tropsch. I have concluded that Dr. Gleason has not shown that the challenged claims of the '876 patent cover subject matter that would have been obvious based on these references to a person skilled in the art at the time of the invention.

81. In my opinion, a POSA would not have been motivated to combine Coulson-122 and Badyal. First, a POSA would recognize that there are significant differences between preparing a protective coating for an electronic device and an oil or water repellent coating a fabric. In particular, electronic devices “are very sensitive to damage caused by liquids.” (Ex. 1004 at 1:10–11.) Coulson-122 acknowledges that “[c]ontact with liquids either in the course of normal use or as a result of accidental exposure, can lead to short circuiting between the electronic components, and irreparable damage to circuit boards, electronic chips etc.” (*Id.* at 1:11–15.) Accordingly, a protective coating for an electronic device needs to meet more stringent requirements than a coating for fabrics, which face few adverse consequences if the fabric is exposed to liquids. For example, a coating for electronics must be uniform, conformal, compliant, and sufficiently labile to retain its function during handling or bending (such as when a button is pressed). (Ex. 1001 at 3:40–54.) A POSA would not be motivated to look to a reference focused

on coatings that are particularly suited for providing oil and water repellency for fabrics when seeking guidance on how to satisfy the much more stringent protective requirements for electronic devices. A POSA would also understand that the properties of plasma polymerized materials are determined by the interactions between plasma exited species and the depositing film surface. Differences in the composition, uniformity and roughness of the substrate would also have an effect on the resulting coating. For example, POSAs would know that surface roughness effects hydrophobicity, and that coatings deposited on a naturally rough fabric would not necessarily produce the same hydrophobicity on a smooth electronic device surface.

82. A POSA would understand that crosslinked polymers tend to be more stiff and rigid compared to non-crosslinked polymers. Such rigidity is not always desirable for electronic devices. For example, Coulson-122 addressed the problem of protecting electronic devices, such as microphones, while also not having an “adverse impact on sound quality.” (Ex. 1004 at 2:11–12, 15.) Increased polymer rigidity caused by using a crosslinker may negatively impact the sound quality of electronic devices having microphones or speakers, such as mobile phones, discouraging a POSA from incorporating a crosslinker.

83. Other considerations would dissuade a POSA from adding a crosslinker

to the monomers disclosed in Coulson-122 or Badyal. The increased rigidity that can result from adding a crosslinker may be undesirable for movable components, such as buttons and switches, as movement could cause cracking which can compromise the coating. Further, Coulson-122 shows that a coating with oil- and water-repellant properties can be achieved without the need for a crosslinker. (*Id.* at 4:29–5:6.) A POSA would be motivated to achieve a more economical process. Accordingly, a POSA would be motivated to minimize the number of reagents and would not reach for additional, unnecessary reagents, especially considering such an addition could also negatively impact the performance of the coating. Adding more reagents also increases the complexity of a plasma polymerization process and presents additional challenges delivering multiple reactants uniformly. If reactants are not delivered uniformly, the resulting polymer will be non-uniform and can be non-conformal.

84. A POSA reviewing the Coulson-122 and Badyal references would understand that Coulson-122 was published more than 7 years after Badyal. Despite the references having overlapping inventors (Stephen Coulson), Coulson-122 never suggests that a crosslinker would improve a protective coating for electronic devices. A POSA therefore would be skeptical that the crosslinkers disclosed in Badyal would improve the protective coating for electronics disclosed in Coulson-

122 when Coulson-122 itself does not disclose or suggest incorporating Badyal's crosslinkers.

85. As discussed above, A POSA would not read Badyal's disclosure to be so expansive as to include crosslinkers of formula (I) having any bridging group Z known in the polymer art. Accordingly, Badyal would not have motivated a POSA to select a bridging group from any of the unrelated secondary references—Cohen, Holliday, Padiyath, Francesch, and Tropsch—instead of a “particularly preferred” group described by Badyal's formula (II). Further, none of the asserted secondary references (Cohen, Holliday, Padiyath, Francesch, or Tropsch) provide any disclosure or teaching that the crosslinking compounds identified by Petitioner would be suitable for use with the monomer compound recited in claim 1, or in particular with PFAC8 or PFMAC8, either in a conventional polymerization process, or in a plasma polymerization process. In addition, none of those crosslinking compounds are disclosed or suggested by Badyal. Accordingly, a POSA would lack motivation to combine the cherry-picked crosslinking compounds from the secondary references with the monomers disclosed in Coulson-122 or Badyal.

86. Cohen, Holliday, and Tropsch each fail to show their crosslinkers would yield crosslinked polymers having oil or water repellant properties when used

in plasmas so would not be suitable crosslinkers according to Badyal. Cohen does not describe using DVTMDS in a plasma nor does it describe that DVTMDS would be used to create crosslinked polymers having oil or water repellant properties. Instead, Cohen describes that copolymers made using DVTMDS could be used “alone or in combination with other insulating materials.” (Ex. 1006 at 5:2–7.)

87. Holliday also fails to describe that BDVE or DCHD could be used in plasma or to create polymer having oil or water repellant properties. Instead, Holliday describes using crosslinkers in compositions for “use in electrical insulating applications.” (Ex. 1007 at 1:22–23.)

88. Padiyath describes multilayer films including polymer and diamond-like carbon layers (Ex. 1008 ¶¶ 5–7, 25, 26, 52.) Padiyath teaches away from providing a single layer polymer coating, stating that multiple different layers of alternating inorganic layers separated by polymer coatings are required for superior barrier performance:

It is commonly accepted that *multiple inorganic layers separated by polymer coatings are needed to achieve superior barrier performance.*
(Ex. 1008 ¶ 3) (emphasis added.)

Adding more layers may improve the lifetime of the assemblies by increasing their imperviousness to oxygen, moisture, or other

contaminants. Use of more or multiple layers may also help cover or encapsulate defects within the layers. (Ex. 1008 ¶ 26.)

Accordingly, Padiyath would lead a POSA away from forming a single layer coating as claimed in the '876 patent. For this reason, a POSA would not be motivated to combine Padiyath with Coulson-122 or Badyal.

89. Although Padiyath mentions plasma polymerization as one possible way to form the polymer layer, it does not suggest combining a monomer and a crosslinking reagent in a plasma as required in claim 1. Instead, Padiyath focuses on “crosslinking the layer to form the polymer in situ, e.g., by flash evaporation and vapor deposition of a radiation crosslinkable monomer, followed by crosslinking using, for example, an electron beam apparatus, UV light source, electrical discharge apparatus or other suitable device.” (Ex. 1008 ¶¶ 52, 61.) The process described in Padiyath leads away from applying a crosslinking reagent in combination with a monomer in the plasma by teaching a preference for crosslinking in-situ after polymer layers have already been formed.

90. Tropsch does not show using HDVE in a plasma nor does it describe that HDVE would be used to create crosslinked polymers having oil or water repellant properties.

91. Cohen, Holliday, and Tropsch each fail to teach use of the claimed

crosslinking reagent in connection with producing a protective coating for an electronic device via a *plasma* polymerization process. As discussed above, the structure of a coating obtained by plasma polymerization is inherently unpredictable, a POSA would not have a reasonably expected to succeed in combining the crosslinkers identified by Petitioner from these references with the monomers described in Coulson-122 and Badyal to produce a protective coating via a plasma polymerization process.

92. A POSA would not have a reasonable expectation of success in combining Padiyath with Coulson-122 and Badyal. Padiyath discloses a multilayer film including a crosslinked polymer layer. (Ex. 1008 ¶ 52.) Padiyath however does not describe the polymer layer as a barrier layer and, rather, refers to the layer as one layer in the multilayer stack of the barrier assembly. (*Id.* ¶ 51.) Padiyath teaches away from the claimed invention by stating multiple inorganic layers separated by a polymer layer are needed to achieve superior barrier performance. (*Id.* ¶ 3.) In reading, Padiyath a POSA would not expect successful barrier properties from the crosslinked polymer layer alone. Further, Padiyath fails to teach use of the claimed monomer compound and crosslinking reagent together in its polymer layer. Accordingly, even if a POSA would have been motivated to combine Padiyath with Coulson-122 and Badyal, they would not have a reasonable expectation of success

in arriving at the claimed invention of claim 1.

93. Francesch involves the fabrication of bioactive surfaces using plasma polymerization of a monomer, PFM, which is not disclosed in the '876 patent, with and without a crosslinker. (Ex. 1009 at 605.) Francesch does not describe that the crosslinker could be used to obtain a protective coating for an electronic device. Rather, Francesch focuses on properties such as the surfaces' ability to bind biological molecules. (*Id.* at 605, 610.) It does not discuss properties, such as water contact angle or resistance, which the '876 patent considers relevant to producing an effective protective coating for an electronic device. (Ex. 1001 at 3:55–4:35.) Francesch also fails to show use of the crosslinker with the claimed monomer compounds or it could be used to obtain a protective coating for an electronic device using those compounds. Accordingly, a POSA would not have a reasonable expectation of success in combining Francesch with Coulson-122 and Badyal to arrive at the invention of claim 1.

XI. CLAIMS 2–15 ARE NOT OBVIOUS BASED ON THE COMBINATION OF COULSON-122, BADYAL, AND EACH OF COHEN, HOLLIDAY, PADIYATH, FRANCESCH, AND TROPSCH

94. For the purposes of the preliminary response, I have not been asked to review the dependent claims 2–15 for any of the asserted grounds. However, claims 2–15 each depend from claim 1, and therefore include all of the limitations of claim

1. For at least the reasons stated with respect to claim 1 for each of the asserted Grounds, I have concluded that Dr. Gleason has not shown that the challenged claims of the '876 patent cover subject matter that would have been obvious based on the asserted references to a person skilled in the art at the time of the invention.

I hereby declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: October 30, 2020

By: _____

Gregory N. Parsons, Ph.D.

GREGORY N. PARSONS, Ph.D.

Narrative:

Gregory Parsons is Celanese Acetate Professor of Chemical and Biomolecular Engineering at North Carolina State University. He received a Bachelor's degree in Physics from the State University of New York and a PhD in Physics in at NC State University studying Plasma CVD of Hydrogenated Amorphous Silicon. In 1990 he began a postdoc at IBM TJ Watson Research Center working on thin film transistor materials for flat panel displays, and joined NC State Chemical Engineering in 1992 as an Assistant Professor to explore surface reactions in thin film materials, including Atomic Layer Deposition. In 2001 he initiated the annual International AVS ALD Conference where he remains in active leadership. He has published more than 200 articles in reaction mechanisms during atomic layer deposition and molecular layer deposition, ALD on polymers and fibers, ALD for metal organic frameworks, reaction system scaling, ALD for energy storage and harvesting, as well as selective area ALD for advanced electronic devices. He was elected Fellow of the American Vacuum Society in 2005, and he served from 2011-2013 on the AVS Board of Directors. He is the recipient of an NSF Career Award, the Alcoa Foundation Distinguished Engineering Research Award, and a Semiconductor Research Corporation Invention Award. He is also an accomplished classroom teacher, being named to NC State's Academy of Outstanding Teachers in 2009. He is the 2014 recipient of NC State's RJ Reynolds Award, the College of Engineering's highest distinction for faculty research, teaching and service. In 2015 he received the ALD Innovation Award, the highest recognition of accomplishment in the ALD community, and in 2016 was named to the inaugural class of the NC State Research Leadership Academy.

Education

Post-doctoral Researcher, 1990-92, IBM T.J. Watson Research Center
Ph.D. Physics, May 1990, North Carolina State University
B.A. Physics, May 1980, State University of New York, College at Geneseo

Research and Employment Experience

2020 – : Associate Faculty, Department of Physics, NC State University
2018 – : Celanese Acetate Professor Dept. of Chemical and Biomolecular Eng., NC State Univ.
2009 – 2018: Alcoa Professor Department of Chemical and Biomolecular Eng., NC State Univ.
1993 – : Adjunct Faculty, Department of Materials Science and Eng., NC State University
2012 – 2014: Visiting RTI Senior Fellow Research Triangle Institute, RTP NC (half-time)
2002 – 2009: Professor, Department of Chemical and Biomolecular Eng., NC State Univ.
1998 – 2002: Associate Professor, Department of Chemical Engineering, NC State University
1992 – 1998: Assistant Professor, Department of Chemical Engineering, NC State University
1990 – 1992: Post-Doctoral Researcher, IBM T.J. Watson Research Center, Yorktown Heights, NY
1984 – 1990: PhD Student, Dept. of Physics, NC State University (Advisor: Gerald Lucovsky)

1980 – 1984: Research Technician, GTE Laboratories, Waltham Massachusetts

Litigation and Expert Experience

Consultation

- 2017-2018: Civil Action No. 1:16-cv-11249-WGY, Harvard University vs. Micron Technology Inc., US Patents Nos. 6,969,539, 7,507,848, 8,334,016.
- 2016: Harvard University vs. Global Foundries Inc., US Patents Nos. 6,969,539, 7,507,848, 8,334,016.
- 2016: TSMC Inter Partes Review Petition, U.S. Patent Nos. 6,521,911, 6,734,069.
- 2013-14 Ziptronix, Inc. v. OmniVision Technologies, Inc., et al., Case No. 4:10-cv-05525-SBA (EDL). U.S. Patent Nos. 7,387,944, 7,335,572, 7,553,744, 7,037,755, 6,864,585, 7,807,549, 7,871,898, 8,053,329, 8,153,505.
- 2011: International Trade Commission Investigation 337-TA-749 Regarding Certain LCD Devices

Trial

- 2011 Thomson Licensing v. Qisda et al., International Trade Commission Investigation 337-TA-749. Trial testimony on behalf of the plaintiff

Deposition

- 2011 Thomson Licensing v. Qisda et al., International Trade Commission Investigation 337-TA-749. Deposition testimony on behalf of the plaintiff

Reports

- 2017 Infringement upon U.S. Patent 6,969,539
Infringement upon U.S. Patent 7,507,848
Infringement upon U.S. Patent 8,334,016
- 2011 Infringement upon U.S. Patent 5,621,556
Infringement upon U.S. Patent 5,978,063
Validity of U.S. Patent 5,621,556
Validity of U.S. Patent 5,978,063

Web of Science: 273 publications, 7055 citations, h-factor = 46

Google Scholar: 9954 citations, h-factor = 54

Research interests: Semiconducting and electronic materials and devices. Atomic layer deposition of thin films. Electronic and photoactive materials and devices. Surface reactions in atomic and molecular layer deposition of inorganic and organic materials. Organic/inorganic interfaces and interface formation chemistry. Fundamental modeling and experiments of surface modification and deposition reactions.

Awards and Recognition

2019 Top Reviewer, ACS Chemistry of Materials
2018 Celanese Acetate Professorship
2017 Alumni Distinguished Graduate Professorship Award
2017 *AVS Journal of Vacuum Science and Technology* Most Valuable Reviewer
2016 Alumni Association Outstanding Research Award
2016 NC State Research Leadership Academy
2015 NC State Thank a Teacher Recipient
2015 International ALD Innovation Award
2014 RJ Reynolds Award for Research Teaching and Extension
2012 Visiting Senior RTI Fellow
2011 Named Nanotechnology Thought Leader by Nanowerk.com
(<http://www.nanowerk.com/news/newsid=21124.php>)
2009 Alcoa Professorship
2009 NC State Alumni Outstanding Teacher Award
2009 NC State Outstanding Teacher Award, Member, Academy of Outstanding Teachers
2008 Alcoa Foundation Distinguished Engineering Research Award
2006 Invited PhD Opponent, Helsinki University of Technology, Helsinki Finland
2005 AVS Fellow
2000 SRC Invention Award
1999 Alcoa Foundation Engineering Research Achievement Award
1996 NSF Faculty Early Career Development Award
1991 IBM First Patent Award
1989 Materials Research Society Student Research Award
1988 Elected to Sigma Pi Sigma, Physics Honor Society
1980 Geneseo Alumni Scholarship, highest physics GPA

Professional Society Memberships

American Institute of Chemical Engineering
American Vacuum Society
Sigma Pi Sigma: National Physics Honor Society

Service and Outreach

Professional Service

2018 – HERALD Grant Committee
2018 - American Vacuum Society, International Interactions Committee Chair
2017 – ALD Academy – Founder and Lecturer
2018 3rd Area Selective Deposition Workshop, Program Chair
2017 DTRA Science Review, Host and Organizing Committee

2015 - 2017 American Vacuum Society, Publications Committee Chair
 2013 - 2014 American Vacuum Society, International Interactions Committee Chair
 2010 - 2013 American Vacuum Society, Board of Directors
 2008 - 2010 NC Nanotechnology Commercialization Conference, Organizing Committee
 2001 - International Atomic Layer Deposition Conference, Program Committee
 2003 - 2010 Journal of Vacuum Science and Technology, Associate Editor
 2001 - 2010 Journal of Vacuum Science and Technology, Editorial Board,
 2003 International Atomic Layer Deposition Conference, Conference Chair
 2001 International Atomic Layer Deposition Conference, Conference Originator
 2000 - 2003 MRS Symposium Advisor, Symposium A, Amorphous Silicon Materials
 1999 - 2000 American Vacuum Society, Thin Film Division Chair
 1997 - 2000 American Vacuum Society, Thin Film Division Program Committee
 1997 - 1998 MRS Symposium Chair, Flat Panel Display Materials

University Service

2019 – 2020 Chair, NC State Research Leadership Academy
 2019 Chair, 2019 NC State University Research Symposium
 2018 – 2019 Chair-Elect, NC State Research Leadership Academy
 2017 – METRIC Magnetic Resonance User Committee
 2017 – COE representative, Plant Sciences Building Planning Committee
 2016 – 2018 Member, NC State Research Leadership Academy
 2012 – 2016 GAANN NEEM Scholarship PI
 2012 – 2015 University Liaison, Research Triangle Institute
 2006 – 2014 Nanotechnology Initiative, Director
 1995 – 2012 GAANN EIMat/NEEM Scholarship Committee
 2010 – 2011 Chancellor's Research and Scholarship Strategic Planning Committee
 2010 – 2011 Vice Chancellor's Research Facilities Steering Committee
 2009 – 2010 College of Textiles Faculty Search Committee
 2005 – 2009 Intellectual Property Committee
 2008 Vice Chancellor for Research and Graduate Studies Search Committee
 2005 – 2006 Nanotechnology Steering Committee

Department Service

2019 – 2020 Chair, Post-tenure Review Committee
 1995 – Undergraduate Advisor, Electronic Materials/Nanoscience Option
 2015 - 2016 Faculty Search Committee
 2010 – 2011 Faculty Search Committee, Chair
 2010 – 2011 Post-tenure Review Committee
 2008 – 2010 Graduate Student Recruiting Committee
 2009 – 2010 College of Textiles Faculty Search Committee
 2003 – 2006 Faculty Search Committee, Chair
 1999 – 2006 Faculty Search Committee
 2002 – 2003 Awards Committee
 1996 – 1999 Graduate Student Recruiting Committee, Chair
 1999 Centennial Campus Building Design Committee
 1993 – 1996 Graduate Student Recruiting Committee
 1995 COE Open House, ChE Organizer

Consulting

2011 - VaporPulse Technologies
1998 - National Science Foundation
2011 Thomson Licensing, Kirkland and Ellis LLP
2008 - 2010 Alditri Technologies
2005 Dow Corning
1998 Environmental Protection Agency
1997 - 1998 Becton Dickinson
1993 - 1994 Tokyo Electron

Journal Review Assignments

Reviewed many journals for:

American Chemical Society
Nature
Electrochemical Society
Elsevier
American Vacuum Society
American Institute of Physics

Outreach, Community Interactions, and Research Leadership

2017 – present: **ALD Academy:** In collaboration with Prof. Erwin Kessels at Eindhoven Technical University in The Netherlands, Parsons inaugurated the ALD Academy to provide tutorial lectures, free of charge (only asking for travel reimbursement), to groups or conferences interested in learning about ALD. To date, we presented lectures to several hundred participants in several locations in Europe, Asia and America.

2016 – present: **ASD Workshop:** Parsons worked with Annelies Delabie at IMEC in Belgium to found the annual Area-Selective Deposition (ASD) Workshop, attracting international academic and industrial researchers to discuss research in thin film nucleation and patterning. Parsons organized and chaired the 2018 ASD Workshop at NC State in Raleigh, attracting more than 150 participants.

2007 – present: **NC State NanoDays.** Parsons research group participates in NanoDays, bringing more than 3,000 K-12 teachers and students to NC State to see and learn about nanoscience and nanotechnology activities on campus. Parsons group members regularly contribute to other science and engineering K-12 and community events.

2008 – present: **Technology Translation and Entrepreneurship:** Parsons pushes technology transfer from his lab by working with former students to create start-up companies, including VaporPulse Technologies (2010-present) and Alditri Technologies (2008-2010). VaporPulse income grew substantially in 2015, and is engaged in several SBIR and private contracts.

2014 – 2015: **Research Triangle Institute Liaison to NC State University.** Parsons collaborated with Jackie Olich, RTI Director, University Collaborations, to promote the RTI Visiting Scholars Program and other interactions between RTI and NC State researchers. Position was transferred to Rick Liston in the NC State Office of Research, Innovation and Economic Development in January 2015.

2012 – 2013: **Visiting Senior Fellow at Research Triangle Institute and RTI Liaison to NC State University.** The position was created to improve NC State's communications with RTI, and to seek ways to improve research collaborations. As part of his role, Parsons worked with researchers in RTI's Solar Fuels Center, the Center for Aerosol and Nanomaterials Engineering and the Center for Materials and Electronic Technologies.

- 2013: ***RTI Visiting Scholars:*** As RTI Liaison, Parsons conceived and formally proposed development of RTI Visiting Scholars Program to RTI leadership. His program was accepted and announced to the North Carolina academic community in December 2013. The program provides funding for University faculty from the RTP region and elsewhere to partner with RTI researchers and build collaborations to address outstanding science and social challenges. The program continues with strong support.
- 2006 – 2014: ***Nanotechnology Initiative:*** Parsons conceived, secured funding and led the NC State Nanotechnology Initiative, designed to build external visibility in nanotech, coordinate and promote interdisciplinary nanotech research across the university, and develop outreach to the K-12 community. New nanotech research programs started at NC State during this time include an NSF Center for Chemical Innovation, the NSF Assist ERC, the DoE Power America Hub, the NSF Research Triangle Nanotechnology Network, and others. The Initiative also supported development of the NanoDays outreach program, led by Gail Jones in the NC State Dept of Education, which interacts with more than 2000 K-12 students and teachers from across NC every year.
- 2012: ***Governor's Luncheon:*** Invited by Governor Bev Purdue to discuss with other leaders ways to broaden commercial opportunities for new technologies.
- 2009: ***Pubic Lectures on Nanotechnology:*** Parsons presented eight public lectures regarding Nanotechnology and Society to groups including Raleigh Rotary Club (Dec. 8), NC State Faculty Scholars Forum (Oct. 12), NC Biotechnology Center Nano Summit (Oct. 8), Federation of Defense & Corporate Counsel (NY, NY, Sept. 11), Tech Transfer Interaction Meeting (July 30), NanoDays (April 24), NC Nanotech Commercialization Conf. (March 26), and the Sanford NC Rotary Club (March 17).
- 2008: ***NC Nanotech Commercialization Conference:*** Led by John Hardin in the North Carolina Department of Commerce, Parsons helped develop and promote the first North Carolina Nanotech Commercialization Conference to connect academics with industry leaders to address challenges in Nanotech Industries. The conference continues now as the Nanomanufacturing Conference, held in Greensboro in fall 2015.
- 1992 – present: ***Cross-Disciplinary Research:*** Led and/or promoted cross-disciplinary Research Center activity, including NCSU ERC for Advanced Electronic Materials Processing, SRC/SEMATECH Front-End-Processing Center, STC for Environmentally Friendly Solvents and Processes, the NC State Nanotechnology Steering Committee, and the NC State Nanotechnology Initiative. Parsons currently collaborates with Jacob Jones, Director of the Research Triangle Nanotechnology Network to attain equipment and build capacity for external research interactions.

Educational and Mentoring Contributions

Research Mentoring

Current research group: 10 PhD students, 1 Visiting PhD student, 2 Senior Researchers, 2 Postdocs, 4 BS students.

Graduated/Completed group members: 13 postdocs, 34 PhD, 6 MS, 68 BS, 2 High School students.

Former PhDs and postdocs in tenured or in tenure-track academic positions: 8, including positions at: University of Alabama, Tuscaloosa, University of Maryland, Baltimore County, North Carolina State University, James Madison University, and others.

Mentoring of underrepresented groups: Current and former group members (including graduate, undergraduate, postdocs and visiting scientists) total more than 130 individuals. These include 34 females, 4 African Americans and 1 Hispanic. I continue to seek opportunities within the University and elsewhere to recruit and support students and postdocs from underrepresented groups.

PhD Theses Directed

	Student	Start	Finish	Degree	Current Position
1.	Easwar Srinivasan	8/92	5/97	Ph D.	Lam Research, Tualatin OR
	Thesis: Fundamental Surface Reactions in Amorphous Silicon Deposition				
2.	Tom Yang	8/93	9/98	PhD(ECE)	Unipac Optoelectronics, Taiwan
	Thesis: Full Self Aligned a-Si TFT's and TFT's on plastic substrates				
3.	Ashfaque Chowdhury	8/94	5/99	PhD	General Electric, Cleveland OH
	Thesis: In-situ Characterization of Plasma Deposition Processes				
4.	Tonya Klein	8/94	8/99	PhD	Associate Prof., U Alabama
	Thesis: Advanced Dielectrics for TFT's and for CMOS Devices				
5.	James J Chambers	8/95	7/00	PhD	AMD, Austin TX
	Thesis: Physical and Electrical Properties of Yttrium Oxide High-k Dielectrics				
6.	Atul Gupta	8/96	8/01	PhD	Varian Semiconductor, MA
	Thesis: Reactions in Silicon and Low Temperature SiO ₂ Deposition				
7.	Dong Niu	8/97	8/02	PhD	Lam Research, Tualatin OR
	Thesis: Chemical Vapor Deposition of High-k Dielectrics				
8.	Kevin Bray	8/97	8/02	PhD	K-Systems, Dayton Ohio
	Thesis: Surface Transport Processes During Deposition on Hydrogenated Amorphous Silicon				
9.	Jason Kelly	8/98	12/05	PhD	Commissioning Agents, Inc
	Thesis: Surface Reactions in high-k dielectric deposition				
10.	KeiJin Park	8/00	12/05	PhD	Samsung, Seoul Korea
	Thesis: Atomic Layer Deposition of Ru and Rh for metal gate electrode applications				
11.	Changwoong Chu	8/01	12/05	PhD	Samsung, Seoul Korea
	Thesis: Nanoscale electrode patterning and molecular electronic junction analysis				
12.	David Terry	8/00	5/06	PhD	Quality Chem. Labs, Wilmington NC
	Thesis: Atomic layer deposition of high-k dielectrics and metal gate electrodes				
13.	Kevin Hyde	8/03	8/07	PhD, Textiles	Glen Raven, SC
	Thesis: Layer-by-layer and atomic layer deposition of films on textile fibers				
14.	Sang Oh	6/03	12/07	PhD (MSE)	Lam Research, Fremont CA
	Thesis : In-situ analysis of low temperature metal ALD				
15.	Qing Peng	8/04	6/09	PhD	Univ. Alabama Tuscaloosa
	Thesis: Nanoscale Engineering of Materials with Supercritical Fluid and Atomic Layer Deposition				
16.	Jeong-Seok Na	8/04	7/09	PhD	Lam Research, Fremont CA

Thesis: Nanoscale Assembly for Molecular Electronics and In Situ Characterization During Atomic Layer Deposition

17. Joe Spagnola 6/05 5/10 PhD (MSE) 3M, Minnesota
Thesis: Polymer and Fiber Modification using Atomic Layer Deposition
18. Bo Gong 8/07 5/12 PhD Lam Research, Tualatin OR
Thesis: Reactions during Atomic Layer Deposition on Polymers
19. Kyoungmi Lee 8/08 8/13 PhD Postdoc MIT Dept of Chem Eng
Thesis: Atomic Layer Deposition on Cotton and ALD Nanosheets
20. Do-Han Kim 8/08 8/13 PhD Postdoc MIT Dept of Chem Eng
Thesis: ALD for Dye-Sensitized Solar Cells
21. Christina Devine 8/08 7/13 PhD US Patent Office, Wash DC
Thesis: ALD on Carbon Nanotubes and Mechanical Modification of Polymers
22. William Sweet 8/09 6/14 PhD Northrup Grumman, Baltimore MD
Thesis: Application of Conductive Thin Films and Selectively Patterned Metal Oxide Coatings on Fibers by Atomic Layer Deposition.
23. Sarah Atanasov 8/10 6/15 PhD Components Research, Intel, OR
Thesis: Substrate-Selective Growth and Organic / Inorganic Materials Integration by Atomic and Molecular Layer Deposition
24. Moataz Mousa 8/10 9/15 PhD ASM, Phoenix Arizona
Thesis: High Throughput Atomic Layer Deposition Processes: High Pressure Operations, New Reactor Designs, and Novel Metal Processing
25. Berc Kalanyan 8/09 12/15 PhD NIST, Gaithersburg MD
Thesis: Atomic Layer Deposition for Electronic Applications: Metal Interconnects, Conductive Textiles, and Photoelectrodes.
26. Halil Ibrahim Akyildiz 8/10 12/15 PhD, MSE (w/Jess Jur) Postdoc, NC State
Thesis: Formation of Organic-Inorganic Hybrid Materials by Sequential Vapor Infiltration
27. Junjie Zhao 8/11 4/16 PhD Postdoc - MIT Dept of Chem Eng.
Thesis: Metal-Organic Framework (MOF) Thin Films on Fibers Enabled by Atomic Layer Deposition (ALD)
28. Erinn Dandley Needham 8/12 6/16 PhD Intel, Portland Oregon
Thesis: Atomic Layer Deposition for the Modification and Creation of Nanomaterials
29. J. Zach Mundy 8/12 6/17 PhD BASF, New Jersey
Thesis: Deposition Processes for Multifunctional Nanocoatings on Polymers
30. Paul Lemaire 8/12 6/17 PhD Lam Research, Tualatin OR
Thesis: Atomic Layer Deposition and Controlling Film and Crystal Nucleation
31. James Daubert 8/12 6/17 PhD Northrup Grumman, Baltimore MD
Thesis: Atomic Layer Deposition for Electrochemical Applications: Energy Storage and Corrosion Protection.
32. Eric Stevens 8/13 5/18 PhD ASM, Phoenix, AZ
Thesis: From Novel Processes to Industrially Relevant Applications: Atomic Layer Deposition of Metal, Metal Oxide, and Metal Carbide Thin Films
33. Jennifer Ovental 8/13 6/18 PhD, with Saad Khan Micross, Durham, NC
Thesis: Methods and processes for molecular scale coupling of organic and inorganic materials
34. Mariah Ritz King 8/13 7/18 PhD, with Erik Santiso NC School of Science & Math
Thesis: Enhanced Materials Analysis Using Engineering Computational Tools for Applications in Electronics Fabrication and Surfactant Production

35.	Wenyi Xi	8/13	4/19	PhD	Postdoc – NC State
	Thesis: Thermal atomic layer etching and vapor phase infiltration for carbon materials synthesis				
36.	Dennis Lee	8/14	4/19	PhD	Postdoc - Johns Hopkins University
	Thesis: Chemical protective metal-organic framework thin films on fiber systems driven by atomic layer deposition				
37.	Heather Barton	8/15		PhD	
38.	Seung Keun Song	8/16		PhD	
39.	Amanda Volk	8/16		PhD	
40.	Siyao Wang	8/16		PhD	
41.	Holger Saare	8/16		PhD, Physics	
42.	Rachel Nye	8/17		PhD	
43.	Jung-Sik Kim	8/17		PhD	
44.	Leah Granger	8/17		PhD (with D. Brenner)	
45.	Sarah Smith	8/18		PhD	
46.	Hwan Oh	8/19		PhD	

MS Students

	Student	Start	Finish	Degree	Current Position
1.	Walter Bill Read	8/93	12/97	MS	Intel, Phoenix Arizona
	Thesis: Low Temperature Selective Area Deposition of Silicon				
2.	Chris Makosiej	8/96	5/99	MS	Schweiserhall, Inc., SC
	Thesis: Barrier Properties of Dielectric Films on Plastics				
3.	Powan Mehan	8/01	8/03	MS	
	Course-only MS				
4.	Tom Abatemarco	8/00	8/03	MS	
	Course-only MS				
5.	Dipak Barua	8/03	5/05	MS	PhD, NC State
	Thesis: Metal Deposition in Supercritical Fluids				
6.	Catherine Yingzhen Lu	8/10	5/12	MS	PhD at UT Dallas

Undergraduate Researchers

	<u>Start</u>	<u>Finish</u>	<u>Current Position</u>
1. Tim Anderson	9/94		5/97 Milliken
2. Steve Ellis	9/95		5/97 Motorola - grad school
3. Daniel Lloyd	1/95		5/96 Proctor and Gamble
4. Jeremy Bordeaux	5/96		1/97UNC Medical School
5. Chris Arthur	5/96	5/98	IBM East Fishkill
6. Andrew Lemonds	1/97	5/99	UT Austin Ph.D. program
7. Thumai Pham	8/98	5/99	Samsung, Texas
8. Kai Wang	1/99	12/99	UC Berkeley Ph.D. program
9. Bill Ketchie	1/00	12/01	UVA CHE Ph.D. program
10. Franklin Goldsmith	1/02	5/02	MIT ChE Ph.D. program
11. Leonard Nelson	8/00	5/02	Notre Dame Business School
12. Tammi Schmitt	5/01	5/02	Consultant, Greenville SC
13. Clint Smoke	8/01	5/02	
14. Scott Burnside	8/00	8/02	GlaxoSmithKline, RTP NC
15. Rob Ashcraft	8/00	8/02	MIT CHE Ph.D. program
16. Bryce Sturdevent	8/02	1/03	PhD Purdue
17. Justin Bennett	8/98	5/03	East Carolina U.
18. Kiel Chapman	1/03	5/03	
19. Jason Doub	1/02	5/04	ATMI Inc, Idaho
20. Joe Spagnola	1/03	5/04	Ph.D. MAT NCSU
21. Katherine Schadel	1/04	5/05	Ph.D. program MIT
22. Justin Hill	5/04	8/05	Ph.D. program UFlorida
23. Paige Auten	5/04	12/04	Ph.D. program Ga Tech
24. Erin D. Young	5/04	8/04	BS REU student
25. Michael Stewart	6/05	8/07	PhD, UC Santa Barbara
26. Linda Bruner	8/05	12/06	
27. Daniel Ruby	1/06	12/06	
28. Eric Petschke	5/06	8/06	Exxon Mobil
29. Zack Conrad	5/06	8/06	
30. Kimberly Ager	5/07	8/07	BS Penn State
31. Justin Wood	5/07	8/07	BS NC State
32. Ryan Van Gundy	10/05	5/08	Connecticut
33. Zach Nicholson	1/07	8/08	
34. Andrew Canton	1/08	8/08	
35. Kelly Roth	5/07	12/08	MS NCSU COT
36. Berc Kalanyan	5/08	8/08	PhD NC State
37. Christine Watson Link	1/07	12/08	PhD UCSB
38. Erin Green	8/08	12/08	
39. Chris Hanson	5/08	5/10	Exxon Mobil, Houston
40. Kai Presler-Marshall (high school student)	5/10	8/10	NC School of Sci and Math
41. Nicholas L. Abram (high school student)	9/10	1/11	Undergraduate, Stanford U.
42. Hanna Reese	1/10	8/10	PhD

43. Michael Carpenter	5/08	5/11	BS NC State
44. Shane Di Dona	8/08	5/11	MS NC State
45. D. Evan Piephoff	1/11	5/11	BS NC State
46. Mariah Woodroof	8/10	8/11	PhD Delaware
47. Barry Hiney	1/10	6/12	Peace Corps, Africa
48. Harshad Srinivasan	1/11	12/11	PhD NC State
49. Ashwin P. Srikrishna	1/11	5/12	BS ChE NCSU
50. Deon Bharrat	5/11	6/12	PhD MSE NC State
51. Nik Sigmon	1/10	5/13	
52. Sven Soltmann	5/11	5/13	BS Mech Eng
53. Michael Naclerio	5/12	12/12	BS Chem Eng
54. Trent Blevins	4/12	12/14	Employed in Raleigh
55. Matt Salmon	5/13	5/15	
56. Billy Nunn	8/13	5/15	PhD ChE Wisconsin
57. Omar Knio	10/13	5/15	PhD ChE GaTech
58. Clayton Shaffer	5/13	5/16	
59. Cailean Pritchard	8/13	5/15	RTI
60. Saif Hassan	10/13	5/17	
61. Allie Cox	8/14	5/16	
62. Hannah Gotsch	7/14	5/16	Industry position
63. Brent White	5/15	5/17	
64. Michael Hinkson	6/16	5/17	Duke MS Program
65. Ian Woodward	6/15	5/17	University of Delaware Chem Eng PhD Program
66. Parker Colbath	1/15	5/17	
67. Kraig Turner	10/16	5/17	
68. Grant Hill	6/14	5/18	
69. Antoine Gremaud	5/16	5/19	Peace Corps
70. Jovenal (Joe) Jamir	5/16	5/19	
71. Alexandra Davis	1/17	5/19	
72. Sara Bartczak	5/17	5/19	
73. Alex Lerner	8/18	8/21	
74. Christopher Downs	10/18	5/19	
75. Nick Carroll	9/19		
76. Andie O'Connell	9/19		
77. Devin Junkins	9/19		
78. Jimmy Donovan	9/19		

Post-Doctoral Researchers/Staff

		<u>Start</u>	<u>Finish</u>	<u>Subsequent Position</u>
1.	D.H. Kim Postdoc	1/94	12/94	Faculty, Chonnam Univ. Gwangju, Korea
2.	M. Fang Postdoc	1/96	11/96	Thomson Microelectronics
3.	Laura Smith Postdoc	1/97	1/01	Staff Position, NSCU AIF
4.	Bill Epling Postdoc	5/99	8/99	Assistant Prof, U. Alabama
5.	Theodosia Gougousi Postdoc	5/01	8/04	Assistant Prof. of Physics UMBC
6.	Elisa Rosa Postdoc	4/04	5/05	Brazil
7.	Daisuke Hojo Postdoc	12/05	9/07	Tohoku University, Sendai, Japan
8.	Giovanna Scarel Postdoc	8/07	8/09	Associate Prof., James Madison Univ.
9.	Jesse Jur Res. Asst. Prof	9/08	12/10	Associate Prof, NCSU TECS
10.	Kim Roberts Sr. Researcher	5/08	8/10	Director of Recruiting, NC State College of Eng.
11.	Mark Losego Res. Assist. Prof	9/11	12/14	Assistant Prof., Ga Tech
12.	Phil Williams Postdoc	1/13	3/15	BASF
13.	Christopher Oldham Postdoc	9/09	12/14	Senior Researcher, NC State
14.	Alexandra Brozena Postdoc	7/13	7/16	Founder/Editor, Advanced English Editing
15.	Mike Mantini Res. Specialist	7/14	7/16	Specialty Trades Technician, NC State
16.	Chris Oldham Sr. Researcher	1/15	12/18	VaporPulse Technologies Inc.
17.	Cheng Cheng Research Assoc.	12/16	5/17	Applied Materials
18.	Michael Fusco Postdoc	2/17	2/19	Wolfspeed, Durham NC
19.	Ian Woodward Temp. Res. Asst.	5/17	4/18	University of Delaware Chem Eng PhD Program
20.	Maryam Khazaei Visiting Postdoc	1/19	3/19	Intel, Phoenix Arizona
21.	Wenyi Xie Postdoc	4/19		
22.	Bruce Ash Research Assistant	4/19		

Thesis Committees (since 2009)

Student	Dept/Degree	Advisor
Hongping Yan	Physics PhD	Harald Ade
Paul Sujata	Physics PhD	Marco Bounjournon-Nardelli
Eun Chu (Julie) Oh	ECE PhD	Paul Franzon
Haiyan Liu	Chem Eng. PhD	Ruben Carbonell
Hyung Jun Koo	Chem Eng. PhD	Orlin Velev
Sumit Gangwal	Chem Eng. PhD	Orlin Velev
Feng He	Chem Eng. PhD	Fanxing Li

Recent Notable PhD Student and Postdoc Achievements and Recognition (since 2011)

2019	Amanda Volk: Featured “Student User Spotlight” interview on NC State’s AIF Website
2019	Holger Saare: Selected to participate in NSF/DOE Quantum Science Summer School
2019	Rachel Nye: Helen & Rolf Illsley Scholarship, Society of Vacuum Coaters Foundation
2018	Siyao Wang: Technical Merit Award, Nonwovens Institute Nov IAB Meeting
2018	Mariah King: Editor’s Pick in <i>Journal of Vacuum Science & Technology A</i>
2018	Dennis Lee: Honorable mention for microscopy, 2018 Envisioning Research contest
2018	Siyao Wang: Best Presentation Award, Nonwovens Institute May IAB Meeting
2018	Siyao Wang: 2 nd Prize, 10 th Triangle Soft Matter Workshop’s Art in Science Competition
2018	Wenyi Xie: Finalist, ALE Best Student Paper Award, ALD/ALE 2018, Korea
2018	Seung Keun Song, Finalist, ALD Best Student Paper Award, ALD/ALE 2018, Korea
2018	Dennis Lee: NC State Schoenborn Symposium, Vivian T. Stannett Fellow
2018	Rachel Nye: Honorable Mention, NSF Graduate Research Fellowship Program
2017	Dennis Lee: ACS Publications, “ACS Editors’ Choice” Recipient
2017	Junjie Zhao: Chinese Government Award for Outstanding Overseas Students
2016 – 2018	Mariah Ritz King: SRCEA Graduate Fellowship
2016	Zach Mundy: North Carolina State University’s Praxair Teaching Excellence Award
2016	Dennis Lee: 5th International Conference on Metal-Organic Frameworks & Open Framework Compounds, Student Support Award
2016	Junjie Zhao: NC State Schoenborn Competition, Runner-up: “Coupling ALD and MOFs”
2016	Dennis Lee: Korean-American Scientists and Engineers 6 th South-Atlantic Regional Conference, 1 st Place Outstanding Poster Award: “UiO-66-NH ₂ Assembly on ALD Oxide Surfaces using β -cyclodextrin and Cetyltrimethylammonium Bromide”
2015	Erinn Dandley, International ALD Conference, Student Award Finalist: “Wafer-Scale Vapor Infiltration Patterning”
2015	Berc Kalanyan: International ALD Conference, Best Poster Award: “Loading Effects during Tungsten Nucleation and Selective Area Deposition”
2015	Junjie Zhao: American Vacuum Society, Thin Film Division Student Award: “MOFs on Fibers using ALD Nucleation Layers”
2015	Eric Stevens: SRC TECHCON 2015: Best in Session Award

2015 Zach Mundy: The Nonwovens Institute Fall Industrial Advisory Board Meeting: Best Student Presentation

2015 Mariah Ritz: FOMMS 2015 Graduate Student Award

2015 Junjie Zhao: Best Paper Award using NCSU AIF Facilities: "Facile Conversion of Hydroxy Double Salts to Metal–Organic Frameworks Using Metal Oxide Particles and Atomic Layer Deposition Thin-Film Templates"

2014 James Daubert: North Carolina State University Certificate of Accomplishment in Teaching

2014 Alexandra Brozena: NSF AIR Pitching Contest, SBIR Phase II Grantees Conference: Third Prize

2014 Sarah Atanasov: Best Paper Award using NCSU AIF Facilities: "Improved Cut-Resistance of Kevlar® using Controlled Interface Reactions during Atomic Layer Deposition of Ultrathin (<50Å) Inorganic Coatings"

2013 James Daubert: U.S. Department of Education Graduate Assistance in Areas of National Need Fellowship

2013 Zach Mundy: U.S. Department of Education Graduate Assistance in Areas of National Need Fellowship

2013 William Sweet: International Atomic Layer Deposition Conference (ALD 2013), 1st place Best Poster Award: "Conductivity and Mechanical Properties of ALD Coated Nonwoven Fibers"

2013 Sarah Atanasov: Schoenborn Symposium, 3rd place poster award: "Nanoscale Modification of Kevlar via Atomic Layer Deposition for Enhanced Force Protection"

2012 Moataz Moussa: Schoenborn Symposium, 2nd place poster award: Effect of Temperature and Gas Velocity on Growth During Atomic Layer Deposition at Atmospheric Pressure"

2012 Sarah Atanasov: Annual AIChE Meeting - Materials Engineering and Sciences III Division, 1st place poster award: "Thermal Protective Properties of ALD Coated Fibers"

2012 Sarah Atanasov: International ALD Conference, Student Award: "Oxidative MLD of PEDOT"

2012 Junjie Zhao: AVS 59th International Symposium & Exhibition: First Place in Art Zone Contest

2011 Moataz Moussa: Local section of AVS MRS ASM meeting: 1st place award, oral presentation

2011 Christopher Oldham: NC State Chancellor's Innovation Fund Award

2011 Christopher Oldham: Poole College of Management Leadership and Innovation Showcase, 1st place award

PhD Student Internships

2019	Siyao Wang	TE Connectivity, Fremont CA
2019	Heather Barton	Micros, Durham NC
2017	Mariah Ritz King	Micron Technology, Inc., Boise ID
2016 - 2017	Eric Stevens	IMEC, Leuven Belgium
2014	Junjie Zhao	Lam Research, Fremont CA
2012	Sarah Atanasov	Intel, New Mexico
2009	Bo Gong	Novellus, San Jose CA
2008	Joe Spagnola	IBM TJ Watson Research Center, NY

Research Group Outreach, Community Interactions, and Service (since 2012)

2018 Christopher Oldham: Volunteer judge, NC State Graduate Student Research Symposium, College of Engineering Division

2017 – Christopher Oldham: Co-Chair, Professional Development Task Force of the NC State Campaign Committee

2017 Parsons Group Service Day - Habitat for Humanity, May 20, 2017.

2017 Ian Woodward: Volunteer, NC Science Olympiad Elementary Event, Marbles Museum

2016 – Parsons Group – Volunteers, NC State NanoDays

2016 – Jenny Ovental: Undergraduate researcher mentor, NC State's Parsons Group

2016 – Mariah Ritz King: High School Small Group Leader, Hope Community Church

2016 – 2017 Mariah Ritz King: Small Pack Leader, International Student Orientation, NC State

2016 – 2017 Heather Barton: Internal VP, Chem and Biomol Eng Graduate Student Association

2016 – 2017 Ian Woodward: Traditions Committee, Goodnight Scholars Program

2016 – 2017 Ali Stieglitz: Volunteer, The Lerner School's Library

2016 Christopher Oldham: Volunteer, Raleigh School Preschool Maintenance Committee

2016 Eric Stevens: Volunteer, K-12 FTC Robotics Competition

2016 Eric Stevens: Weekly 3rd Grade Small Group Leader, Hope Community Church

2016 Ian Woodward: First-Year Mentor and Co-Chair of Shack-A-Thon Committee, Goodnight Scholars Program

2016 Ian Woodward: Team Member, Trinidad & Tobago Alternative Service Break, Trinidad

2016 Ian Woodward: Volunteer, NC Science Olympiad Raleigh Regional Competition

2015 – Jenny Ovental: Animal Foster, Wake County Animal Center

2015 – Jenny Ovental: Volunteer, Habitat for Humanity

2015 – 2016 Jenny Ovental: Recruiting Captain, Chem and Biomol Engineering Graduate Program

2015 – 2016 Jenny Ovental: Volunteer, Centennial Campus Middle School Science Fair

2015 – 2016 Ian Woodward: Executive Committee, Goodnight Scholars Program

2015 Christopher Oldham: Volunteer judge, Regional NC Science and Engineering Fair

2014 – Jenny Ovental, SPCA Dog Volunteer

2014 – James Daubert: NC State Representative, Research Triangle ECS Student Chapter

2014 – Mariah Ritz: Volunteer, Divorce Care for Kids (DC4K); Hope Community Church

2014 – 2016 Mariah Ritz: Volunteer judge, Science Fair at Centennial Campus Middle School

2014 – 2015 Mariah Ritz: Recruiting Captain, Chem and Biomolecular Engineering Graduate Program

2014 – 2015 Mariah Ritz: Social Chair, Chemical and Biomolecular Engineering Department

2013 - 2014 Erinn Dandley Needham: Recruiting Captain, Chem and Biomol Eng Graduate Program

2013 Alexandra Brozena: Volunteer judge, North Carolina 3A Regional Science Fair

2013 Junjie Zhao: Volunteer, AVS 60th International Symposium & Exhibition

2012 – Ali Stieglitz: Volunteer, Mitzvah Day, Jewish Federation of Durham-Chapel Hill

2012 Junjie Zhao: Volunteer, AVS 59th International Symposium & Exhibition

2008 – 2015 Ali Stieglitz: Volunteer event photographer, NC State NanoDays

Undergraduate Advising

2003 – Advisor, BS students in Nanoscience Option, ~15 students per year.

1995 – 2005 Advisor, BS students in Electronic Materials Option

Curricula Developed

2003 Nanoscience Option for Chemical Engineering Undergraduates
– New curriculum to expand and replace the Electronic Materials Option

1995 Electronic Materials Option for Chemical Engineering Undergraduates

Courses Taught

CHE 205 "Chemical Process Principles", Spring, Fall 1993
CHE 225 "Chemical Process Systems", Spring 1994, 1995
CHE 311 "Transport Processes I" Fall 1995-2003, Spring 2005, Spring 2016
CHE 311H "Transport Processes I, Honors Level", Fall 2004 (*Developed course*)
CHE 315 "Chemical Engineering Thermodynamics I" Sp 2006, F 2006-2008
CHE 446 "Chemical Engineering Kinetics", Fall 2009 - 2014
CHE 460/560 "Chemical Processing of Electronic Materials" Sp1997-2004, F 2005, Sp 2008, '14, '16
CHE 495 "Seminar in Chemical Engineering" Spring 1994, 1995
CHE 596C "Fundamental Nano-scale Engineering", Spring 2005, 2007, 2009
CHE 598 "Chemical Processing of Electronic Materials", Fall 1994, Spring 1996
CHE 717 "Chemical Kinetics", Fall 2015, Fall 2017

Research Contributions

Patents Pending

<u>Filed</u>	<u>Docket/Application #</u>	<u>Title</u>
6/20/2017	10620-023WO1 PCT/US2017/038266	Metal-Organic Frameworks and Methods of Making and Use Thereof
1/23/2017	030871-9051-WO00 PCT/US2017/014607	Cellulose Acetate Aerogels
10/22/2016	16208-US 15/331,860	Deposition Process for Corrosion Protection of a Cooling Circuit
4/7/2015	1062.0008-EP 13857504.8	Assemblies and Methods of Stabilization

Disclosures Filed, Currently Active

<u>Filed</u>	<u>Case #</u>	<u>Title</u>
9/6/2016	17044	Electrochemical capacitors derived from cellulose diacetate: Effect of nitric acid, CO ₂ and ALD-based vapor metalation treatments on material and electrochemical performance
4/4/2016	16208	Nanoscale Passivation Coatings for Cooling Channels in Microwave Components
3/14/2016	16202	A Metal-Organic Framework for Broad-Spectrum Protection from Toxic Industrial Chemicals
10/22/2015	16081	Rapid Room-Temperature Synthesis of Metal-Organic Frameworks Using Layered Hydroxy Double Salts
6/25/2015	15291	Mechanically strong, reusable and compostable cellulose diacetate aerogels for oil/chemical spill cleanup

Patents Issued

2018	"Solar Water Splitting in a Molecular Photoelectrochemical Cell" Leila Alibabaei, Matthew Kyle Brennaman, Michael Norris, Gregory N. Parsons, Thomas J. Meyer, US Patent No. 10,119,197
2010	"Nano-structured photovoltaic solar cell and related methods", Gregory N. Parsons, US Patent No. 7,655,860
2004	"Non-crystalline oxides for use in Microelectronic, Optical and other Applications", G.N. Parsons and G. Lucovsky, US Patent No. 6,787,861.
2003	"High Dielectric Constant Metal Silicates Formed by Controlled Metal-Surface Reactions" G.N. Parsons, J.C. Chambers, M.J. Kelly, US Patent No. 6,521,911.
1992	"Pulsed Gas Plasma Enhanced Chemical Vapor Deposition of Silicon", J. Batey, J. Boland and G.N. Parsons, US Patent No. 5,242,530.

2020

- 249 Barton, H. F.; Davis, A.; Parsons, G. N. The effect of surface hydroxylation on MOF formation on ALD metal oxides: MOF-525 on TiO₂/polypropylene for catalytic hydrolysis of chemical warfare agent simulants. *ACS Applied Materials and Interfaces*, **2020**, Just Accepted.
- 248 Dai, Z.; Lee, D. T.; Shi, K.; Wang, S.; Barton, H. F.; Zhu, J.; Yan, J.; Ke, Q.; Parsons, G. N. Fabrication of Freestanding Metal Organic Framework Predominant Hollow Fiber Mat and Its Potential Applications in Gas Separation and Catalysis. *Journal of Materials Chemistry A*, **2020**, DOI: 10.1039/C9TA11701F
- 247 Nye, R. A.; Kelliher, A.; Gaskins, J.; Hopkins, P.; Parsons, G. N. Understanding Molecular Layer Deposition Growth Mechanisms in Polyurea via Picosecond Acoustics Analysis. *Chemistry of Materials*, **2020**, DOI: 10.1021/acs.chemmater.9b0472
- 246 Xie, W.; Parsons, G. Thermal atomic layer etching of metallic tungsten via oxidation and etch reaction mechanism using O₂ or O₃ for oxidation and WCl₆ as the chlorinating etchant. *Journal of Vacuum Science & Technology A*, **2020**, DOI: 10.1116/1.5134430.

2019

- 245 Lee, D. T.; Jamir, J.D.; Peterson, G.W.; Parsons, G. N., "Protective Fabrics: Metal-Organic Framework Textiles for Rapid Photocatalytic Sulfur Mustard Simulant Detoxification" Matter 2019 DOI: 10.1016/j.matt.2019.11.005
- 244 SK Song, H Saare, GN Parsons, Integrated Isothermal Atomic Layer Deposition/Atomic Layer Etching Super-Cycles for Area-Selective Deposition of TiO₂ *Chemistry of Materials*, **2019**, 31, 4793–4804.
- 243 Natalie L. Pomerantz, Erin, E. Anderson, Nicholas P. Dugan, Nicole, F. Hoffman, Heather F. Barton, Dennis, T. Lee, Christopher J. Oldham, Gregory, W. Peterson, Gregory N. Parsons, "Air, Water Vapor, and Aerosol Transport through Textiles with Surface Functional Coatings of Metal Oxides and Metal-Organic Frameworks." *ACS Applied Materials & Interfaces*, 2019, 11, 27, 24683
- 242 Fusco, M. A.; Oldham, C. J.; Parsons, G. N. Investigation of the Corrosion Behavior of Atomic Layer Deposited Al₂O₃/TiO₂ Nanolaminate Thin Films on Copper in 0.1 M NaCl. *Materials* **2019**, DOI: 10.3390/ma12040672
- 241 Dennis, L.; Jamir, J.; Peterson, G.; Parsons, G. N. Water-Stable Chemical-Protective Textiles via Euhedral Surface-Oriented 2D Cu-TCPP Metal-Organic Frameworks. *Small*, **2019**, DOI: 10.1002/smll.201805133
- 240 Parsons, G. N. Functional model for analysis of ALD nucleation and quantification of area-selective deposition. *Journal of Vacuum Science & Technology A* **2019**, DOI: 10.1116/1.5054285
- 239 Min, J. H.; Chen, Y. A.; Chen, I.T.; Sun, T. L.; Lee, D. T.; Li, C. J.; Zhu, Y.; O'Connor, B. T.; Parsons, G. N.; Chang, C. H. Conformal Physical Vapor Deposition Assisted by Atomic Layer Deposition and Its Application for Stretchable Conductors. *Advanced Materials Interfaces*, **2019**, DOI: 10.1002/admi.201801379

2018

- 238 Xie, W.; Khan, S.; Rojas, O.; Parsons, G. N. Control of Micro- and Mesopores in Carbon Nanofibers and Hollow Carbon Nanofibers Derived from Cellulose Diacetate via Vapor Phase Infiltration of Diethyl Zinc *ACS Sustainable Chemistry & Engineering* **2018**, DOI: 10.1021/acssuschemeng.8b02014

- 237 King, M. X.; Theofanis, P.; Lemaire, P. C.; Santiso, E.; Parsons, G. N. Ab initio Analysis of Nucleation Reactions during Tungsten Atomic Layer Deposition on Si(100) and W(110) Substrates. *Journal of Vacuum Science and Technology A* **2018**, DOI: 10.1116/1.5044740
- 236 Stevens, E. C.; Mousa, M. B. M.; Parsons, G. N. Thermal atomic layer deposition of Sn metal using SnCl₄ and a vapor phase silyl dihydropyrazine reducing agent. *Journal of Vacuum Science and Technology A*, **2018**, DOI: 10.1116/1.5055212
- 235 Cui, K.; Lemaire, P. C.; Zhao, H.; Savas, T.; Parsons, G. N.; Hart, A.J. Tungsten-Carbon Nanotube Composite Photonic Crystals as Thermally Stable Spectral-Selective Absorbers and Emitters for Thermophotovoltaics. *Advanced Energy Materials* **2018**, DOI: 10.1002/aenm.201801471
- 234 Dwyer, D.; Lee, D.; Boyer, S.; Bernier, W.; Parsons, G. N.; Jones, W. Toxic Organophosphate Hydrolysis using Nanofiber-Templated UiO-66-NH₂ Metal-Organic Framework Polycrystalline Cylinders. *ACS Applied Materials and Interfaces* **2018**, DOI: 10.1021/acsami.8b08167
- 233 Barton, H. F.; Davis, A. K.; Lee, D. T.; Parsons, G. N. Solvothermal Synthesis of MIL-96 and UiO-66-NH₂ on Atomic Layer Deposited Metal Oxide Coatings on Fiber Mats. *J. Vis. Exp.* **2018**, DOI: 10.3791/57734
- 232 Ives, R. L.; Oldham, C. J.; Daubert, J. S.; Gremaud, A. P.; Collins, G.; Marsden, D.; Bui, T.; Fusco, M. A.; Mitsdarffer, B.; Parsons, G. Corrosion Mitigation Coatings for RF Sources and Components. *IEEE Transactions on Electron Devices*, **2018**, DOI: 10.1109/TED.2017.2788379
- 231 Stevens, E.; Tomczak, Y.; Chan, B. T.; Sanchez, E. A.; Parsons, G. N.; Delabie, A. Area-Selective Atomic Layer Deposition of TiN, TiO₂, and HfO₂ on Silicon Nitride with inhibition on Amorphous Carbon. *Chemistry of Materials* **2018**, DOI: 10.1021/acs.chemmater.8b00017
- 230 Mousa, M. B. M.; Ovental, J. S.; Brozena, A. H.; Oldham, C. J.; Parsons, G. N. Modeling and Experimental Demonstration of High-Throughput Flow-Through Spatial Atomic Layer Deposition of Al₂O₃ Coatings on Textiles at Atmospheric Pressure. *Journal of Vacuum Science and Technology A*, **2018**, DOI: 10.1116/1.5022077
- 229 Xie, W.; Lemaire, P. C. and Parsons, G. N. Thermally Driven Self-Limiting Atomic Layer Etching of Metallic Tungsten Using WF₆ and O₂. *ACS Applied Materials and Interfaces* **2018**, DOI: 10.1021/acsami.7b19024
- 228 Tripathi, A.; Parsons, G. N.; Khan, S. A.; Rojas, O. J. Synthesis of organic aerogels with tailorable morphology and strength by controlled solvent swelling following Hansen solubility. *Scientific Reports*, **2018**, DOI: 10.1038/s41598-018-19720-4
- 2017
- 227 Lee, D. T.; Zhao, J.; Oldham, C. J.; Peterson, G. W.; Parsons, G. N. UiO-66-NH₂ Metal–Organic Framework (MOF) Nucleation on TiO₂, ZnO, and Al₂O₃ Atomic Layer Deposition-Treated Polymer Fibers: Role of Metal Oxide on MOF Growth and Catalytic Hydrolysis of Chemical Warfare Agent Simulants. *ACS Appl. Mater. Interfaces* **2017**, DOI: 10.1021/acsami.7b15397.
- 226 Zhao, J.; Kalanyan, B.; Barton, H. F.; Sperling, B. A.; Parsons, G. N. *In Situ* Time-Resolved Attenuated Total Reflectance Infrared Spectroscopy for Probing Metal–Organic Framework Thin Film Growth. *Chem. Mater.* **2017**, DOI: 10.1021/acs.chemmater.7b03096.
- 225 Lemaire, P. C.; Parsons, G. N. Thermal Selective Vapor Etching of TiO₂: Chemical Vapor Etching via WF₆ and Self-Limiting Atomic Layer Etching Using WF₆ and BCl₃. *Chem. Mater.* **2017**, 29 (16), 6653–6665 DOI: 10.1021/acs.chemmater.7b00985.
- 224 Bagal, A.; Zhang, X. A.; Shahrin, R.; Dandley, E. C.; Zhao, J.; Poblete, F. R.; Oldham, C. J.; Zhu, Y.; Parsons, G. N.; Bobko, C.; Chang, C.-H. Large-Area Nanolattice Film with Enhanced

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Other Publications:

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10. G.N. Parsons, K.J. Park, J.M. Doub, M.J. Kelly, and T. Gougousi “Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning” *Proceedings of Semicon Korea* (2005).
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Invited Seminars and Research Presentations

2019

199. Gregory N. Parsons, "Modeling and Selectivity Loss During Coupled Deposition/Etching ASD Processes", International Area-Selective Deposition Workshop, Leuven Belgium, April 5, 2019
198. Gregory N. Parsons, "ALD Metal Oxide-Mediated MOF Thin Films for Chemical Agent Decontamination", Department of Chemistry, University of Oslo, Oslo Norway, March 7, 2019
197. Gregory N. Parsons, "Chemical Selectivity in Surface Deposition Reactions", Department of Chemical and Biomolecular Engineering, University of Texas at Austin, Austin TX, February 5, 2019

2018

196. Gregory N. Parsons, "Mechanisms for MOF Thin Films on polymer fibers via ALD metal oxides" International Metal Organic Framework Conference, Auckland, New Zealand, Dec. 11, 2018
195. Gregory N. Parsons, "ALD Future Prospects and Perspectives" International HERALD Summit, International Iberian Nanotechnology Laboratory, Braga Portugal, September 27, 2018
194. Gregory N. Parsons, "Adsorptive and Reactive MOF-Fiber Composites" DTRA Science Review, Harvard University, August 17, 2018
193. Gregory N. Parsons, "Research in Area Selective Atomic Layer Deposition and Atomic Layer Etching for Advanced Device Patterning" International Conference on Microelectronics and Plasma Technology, Incheon, Korea July 27, 2018
192. Gregory N. Parsons "Surface-Anchored Metal-Organic-Framework Films on Polymer Fibers", European MRS Conference, Strasbourg, France, June 20, 2018.
191. Gregory N. Parsons "Surface Reactions for Area-Selective Atomic Layer Deposition and Thermal Atomic Layer Etching of Metals and Dielectrics", IITC 2018 Selective Deposition Workshop, San Jose CA, June 4, 2018.
190. Gregory N. Parsons "Surface Reactions for Area-Selective Atomic Layer Deposition and Thermal Atomic Layer Etching of Metals and Dielectrics", ACS Annual Meeting, New Orleans LA, March 20, 2018.

189. Gregory N. Parsons "Chemical Selectivity in Surface Deposition Reactions", Seminar, Department of Chemistry, Carlton University, Ottawa Ontario Canada, January 19, 2018.
- 2017**
188. Gregory N. Parsons "Area-Selective Atomic Layer Deposition of Metals and Dielectrics" 2nd International Workshop on Atomic Layer Deposition: Russia 2017, Sept 25, 2017, St. Petersburg, Russia.
 187. Gregory N. Parsons "Surface-Anchored Metal-Organic-Framework Films on Polymer Fibers", International Workshop on Composites of Metal and Covalent Organic Frameworks: Fundamental Design & Applications, Granada Spain, September 14, 2017.
 186. Gregory N. Parsons "Robust Surface-Anchored UiO-66-based Metal-Organic Framework Films on Polymer Fibers for Rapid Hydrolysis of Chemical Agents", ACS Annual Meeting, Washington DC, August 20, 2017.
 185. Gregory N. Parsons "Using Inherent Substrate Dependent Nucleation to Promote Selective-Area Atomic Layer Deposition" Applied Materials Workshop, San Jose California, July 14, 2017
 184. Gregory N. Parsons "Using Inherent Substrate Dependent Nucleation to Promote Selective-Area Atomic Layer Deposition" American Chemical Society Symposium, San Francisco California, April 5, 2017
 183. Gregory N. Parsons "Nucleation Reactions during ALD and MOF Thin Film Formation" Army Research Laboratory, Adelphi Maryland, March 27, 2017
 182. Gregory N. Parsons "Reactions for Atomically-Precise Thin Film Materials" Lehigh University, Bethlehem Pennsylvania, February 21, 2017
 181. Gregory N. Parsons "Surface Dependent Nucleation During ALD" Lam Research, Tualatin Oregon, February 1, 2017
 180. Gregory N. Parsons "Surface Dependent Nucleation During ALD" University of Helsinki, Helsinki, Finland, January 12, 2016
 179. Gregory N. Parsons "Surface Dependent Nucleation During ALD" Aalto University, Espoo, Finland, January 12, 2016
- 2016**
178. Gregory N. Parsons "Using Inherent Substrate-Dependent Nucleation for Selective-Area ALD of Metals and Metal Oxides" Applied Materials Engineering and Technology Conference, Las Vegas NV, December 14, 2016
 177. Gregory N. Parsons, Junjie Zhao, Dennis T. Lee, Heather F. Barton, Christopher J. Oldham, Howard J. Walls, Gregory W. Peterson "Atomic Layer Deposited Nucleation Layers for Cu-BTC and UiO-66 Based MOF Thin Films" Southeast Regional Meeting of the American Chemical Society, Columbia South Carolina, Oct. 24, 2016
 176. Gregory N. Parsons "Using Inherent Substrate-Dependent Nucleation for Selective-Area ALD of Metals and Metal Oxides" Electrochemical Society Symposium, Honolulu Hawaii Oct 4, 2016
 175. Gregory N. Parsons, Chase Beisel, Albert Keung, Douglas Call, "Computation with Living Cellular Systems" SRC Electronic/Biological Design Automation Workshop, Newcastle University, Newcastle upon Tyne, UK, August 19, 2016
 174. Gregory N. Parsons "Selective ALD for Etch Free Patterning" SRC Project Review, Chicago, Ill, June 8, 2016.

173. Gregory N. Parsons, Berç Kalanyan, Sarah E. Atanasov, Paul Lemaire, Mariah Ritz, Eric Stevens, Chris Oldham and Erik Santiso “Nucleation and Selective-Area Atomic Layer Deposition of Metals and Metal Oxides” Area-Selective Deposition Workshop, IMEC, Leuven Belgium, April 15, 2016
172. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Department of Chemical Engineering, Georgia Institute of Technology, Atlanta, Georgia, March 9, 2016.
171. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Materials Science Institute, Washington University, St. Louis Missouri, January 29, 2016.
170. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Department of Chemistry, Wake Forest University, Winston-Salem North Carolina, January 20, 2016.

2015

169. Gregory N. Parsons, Junjie Zhao, Paul C. Lemaire, Christopher J. Oldham, Philip S. Williams, Howard J. Walls, and Gregory W. Peterson “Highly Adsorptive, MOF-Functionalized Nonwoven Fiber Mats for Hazardous Gas Capture Enabled by Atomic Layer Deposition”, Pacificchem Conference, Honolulu HI, Dec. 2015
168. Gregory N. Parsons “Selective-Area Atomic Layer Deposition of Metals and Metal Oxides”, Shanghai Thin Film Conference, Shanghai China, Oct 25, 2015
167. Gregory N. Parsons “Nucleation Reactions During ALD”, Russian ALD Conference, Moscow Russia, Sept 23, 2015
166. Gregory N. Parsons B. Kalanyan, S. E. Atanasov, E. Dandley, C. Needham, P. Lemaire, M. Ritz, E. Stevens, C. Oldham, E. Santiso “Selective-Area Atomic Layer Deposition of Metals and Metal Oxides by Modified Nucleation and ‘Inverse’ Polymer Patterning”, International ALD Conference, Portland Oregon, June 30, 2015
165. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Moataz Mousa, Eric Stevens, Mariah Ritz, Erik Santiso “Selective ALD for Etch Free Patterning” SRC Review, Boulder Colorado, May 18, 2015
164. Gregory N. Parsons, Sarah Atanasov, Craig Needham “Water-Free Reactions for Selective Area ALD of Dielectrics” SRC Review, Boulder Colorado, May 18, 2015

2014

163. Gregory N. Parsons “Thin Film Materials: Deflecting Pauli’s Devil” RJ Reynold Award Lecture, NC State Univ. Raleigh NC, Nov. 24, 2014
162. Erinn Dandley, Z. Zhu, A. Yoon, L. Sheet, Gregory N. Parsons “Dielectric Nanopatterning Using Selective Sequential Vapor Infiltration” Lam Research Open House, Tualatin Oregon, Nov. 17, 2014
161. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Philip Williams, Craig Needham, Paul Lemaire, Mariah Ritz, Erik Santiso, S. Clendenning, J. Roberts, A. Basu “Controlling Selective Area ALD of Metals and Metal Oxides without the use of Organic Blocking Layers” American Vacuum Society 61st Annual Symposium, Baltimore MD, Nov. 12, 2014
160. Gregory N. Parsons, “ALD Fundamentals and Applications”, NC State/Penn State Center for Dielectrics and Piezoelectrics Short Course, Raleigh NC, Nov. 5, 2014.

159. Gregory N. Parsons, Sarah E. Atanasov, Erinn C. Dandley, Craig Needham, Alexandra Brozena, Philip Williams and Christopher Oldham "New Applications and Ab-Initio Reaction Mechanism Analysis for ALD onto Polymer Fibers and Films" China ALD Conference, Shanghai China, Oct. 17, 2014
158. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Moataz Mousa, Eric Stevens, Mariah Ritz, Erik Santiso "Selective ALD for Etch Free Patterning" SRC Review, Chicago Illinois, Sept. 23, 2014
157. Gregory N. Parsons, Sarah Atanasov, Craig Needham "Water-Free Reactions for Selective Area ALD of Dielectrics" SRC Review, Chicago Illinois, Sept. 23, 2014
156. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Philip Williams, Craig Needham, Moataz Mousa, Mariah Ritz, Erik Santiso "Nucleation and Selective Area Atomic Layer Deposition" Intel SRC Review, Ronler Acres Campus, Hillsboro OR, September 3, 2014
155. Gregory N. Parsons, "Evolving applications of ALD", Israeli Vacuum Society Short Course, Weizmann Institute of Science, Rehovot, Israel, Sept 9, 2014.
154. Gregory N. Parsons, "ALD fundamentals and in-situ characterization", Israeli Vacuum Society Short Course, Weizmann Institute of Science, Rehovot, Israel, Sept 9, 2014.
153. Gregory N. Parsons, "Atomic Layer Deposition for Photoelectrochemical Solar Cells and Photocatalysis", Israeli Vacuum Society Annual Symposium, Herzlyia, Israel, Sept 8, 2014.
152. Gregory N. Parsons, "Studies on ALD nucleation and stabilizing dye bonding to TiO₂", Telluride Surface Chemistry Conference, Telluride CO, July 30, 2014.
151. Gregory Parsons, Junjie Zhao, Paul Lemaire, Philip Williams, Christopher Oldham "Fiber/MOF Integration by ALD" ECBC Working Group, Northwestern University, Evanston Ill, July 15, 2014.
150. Gregory N. Parsons "Atomic Layer Deposition for Photoelectrochemical Water Splitting", European MRS Meeting, Lille France, May 27, 2014.
149. Gregory N. Parsons "Atomic Layer Deposition for Photoelectrochemical and Dye Sensitized Solar Cells", Korean ALD Meeting, Seoul Korea, April 10 2014.
148. Gregory N. Parsons "Selective Area ALD for Etch-Free Patterning", SRC Seminar Webcast. March 20, 2014.
147. Gregory N. Parsons "Atomic Layer Deposition on Fibers and Textiles for Smart Materials Applications", Smart Materials and Coatings Conference, Orlando Florida, Feb 26, 2014.
146. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, "Selective Area Atomic Layer Deposition for Etch-Free Patterning", Intel, Portland Oregon, Jan 9, 2014.

2013

145. Gregory N. Parsons and Erinn Dandley "Atomic Layer Deposition on Polymers and Extension to Selective Area ALD", Lam Research Corporation, San Jose CA Dec 5, 2013.
144. Erinn Dandley and Gregory N. Parsons "Progress in Selective Area ALD using Polymer Infiltration", Lam Research Corporation, San Jose CA Dec 5, 2013.
143. Gregory Parsons "Atomic Layer Deposition for Interface Control and Stabilization in Solar Photoelectrosynthesis Cells", California Institute of Technology, Joint Center for Artificial Photosynthesis, Pasadena CA Nov 20, 2013.

142. Gregory Parsons and Mark Losego "Atomic Layer Deposition for Interface Control and Stabilization in Solar Photoelectrosynthesis Cells", UNC Chapel Hill, Energy Frontier Research Center, Nov 15, 2013.
141. Gregory N. Parsons "Nanoscale Interface Engineering for Solar Energy Utilization", NCSU/Brazil FAPESP Summit Meeting, Raleigh NC, Nov 12, 2013.
140. Gregory Parsons, Junjie Zhao, Mark Losego, Paul Lemaire, Philip Williams, Bo Gong, Sarah Atanasov, Trent Blevins, Christopher Oldham "Absorptive and Reactive Surfaces Enabled by Atomic Layer Deposition" DTRA Program Review, Belcamp MD, Oct 8, 2013.
139. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, "Selective Area Atomic Layer Deposition for Etch-Free Patterning", Applied Materials, San Jose CA, Oct 4, 2013.
138. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, "Selective Area Atomic Layer Deposition for Etch-Free Patterning", SRC Review, Chicago IL, Sept 10, 2013.
137. Gregory Parsons, "Research Directions in Molecular Layer Deposition", Murarta Corporation Visit to Center for Dielectric and Piezoelectric Materials, Raleigh NC June 26, 2013.
136. Gregory N. Parsons "Releasing Hydrogen from Water using Nanoscale Materials and Sunlight" AC21 International Graduate Summer School, Kasetsart University, Bangkok, Thailand, June 3, 2013.
135. Gregory N. Parsons, "High Throughput Atmospheric Pressure Atomic Layer Deposition on Polymers and Fibers", University of Michigan Micro and Nano Manufacturing Workshop, Dearborn Michigan, May 22-23, 2013.
134. Gregory N. Parsons "Future of ALD – Electronics and Patterning", DARPA ALD Workshop, Chicago Illinois, April 22, 2013.
133. Gregory N. Parsons "Vapor phase coating and modification of polymers", Eastman Chemical, Kingsport TN, April 7, 2013.

2012

132. Gregory N. Parsons "Atomic Layer Deposition on Textiles", Harvard University ALD Workshop, Harvard University, Cambridge MA, November 30, 2012.
131. Gregory N. Parsons "Nanoscale Surface Engineering by Atomic and Molecular Layer Deposition" Dept of Chemical Engineering, University of Southern California, Los Angeles CA, Oct 11, 2012.
130. Howard J. Walls, Marty Lail, and David S. Ensor (RTI International) Bo Gong, Christopher J. Oldham, Junjie Zhao, Gregory N. Parsons, (North Carolina State University), Gregory W. Peterson (Edgewood Chemical and Biological Center "Functionalized Nanofibers for Personal Protection Applications" American Association of Textile Chemists and Colorists, September 24, 2012
129. Gregory N. Parsons, "Opportunities and Issues in Nano-Energy Systems" Triangle Institute for Security Studies/ NC State Energy and Security Initiative Luncheon Series, Raleigh, Sept 17, 2012.
128. Gregory N. Parsons and Jesse S. Jur "Continuous Atmospheric Pressure Atomic Layer Deposition Process for Controlled Nanoscale Thin Film Coatings" CMMI Conference, Boston, July 9, 2013
127. Gregory N. Parsons and CJ. Oldham, "Atomic Layer Deposition on Fibers" Arden Fabrics Inc., Detroit MI, April 26, 2012.

126. Gregory N. Parsons, "Nanoscale Surface Engineering by Atomic Layer Deposition" Department of Nanoscience and Nanoengineering Engineering, UNCG, Greensboro, NC April 20, 2012.
125. Gregory N. Parsons, "Nanoscale Surface Engineering by Atomic Layer Deposition" Department of Chemical and Biomolecular Engineering, Vanderbilt University, Nashville TN, March 26, 2012.
124. Gregory N. Parsons and CJ. Oldham, "Atomic Layer Deposition on Fibers" TNO, Eindhoven, The Netherlands, March 22, 2012.
123. Gregory N. Parsons and CJ. Oldham, "Atomic Layer Deposition on Fibers" Levitech Inc., Almere, The Netherlands, March 21, 2012.
122. Gregory N. Parsons, "Progress and Opportunities in Atomic Layer Deposition and ALD Based Chemistry" Taiwan Vacuum Society Meeting, Taipei, Taiwan, January 2012.

2011

121. Gregory N. Parsons, "Surface Engineering of Sustainable Cellulosic Materials by Atomic Layer Deposition" Materials Research Society Fall Meeting, Boston MA, November 30, 2011.
120. Gregory N. Parsons, "Multifunctional Fiber Surfaces by Conformal Vapor Phase Coating" DTRA 2nd Skin Concept Workshop, Natick, MA August 4, 2011.
119. Jesse S. Jur, Bo Gong, Christopher Oldham, William J. Sweet III, Kyoungmi Lee, Joesph C. Spagnola, Gregory N. Parsons and Behnam Pourdeyhimi "ALD for Textiles" 2011 International Atomic Layer Deposition Conference, Boston MA, June 2011.
118. Gregory N. Parsons "Solar Fuels Materials and Devices using Atomic Layer Deposition" Department of Chemical Engineering, Northeastern Univ., Boston, Mar 17, 2011.
117. Gregory Parsons and Jess Jur "ALD at Atmospheric Pressure in a Flow-Tube Reactor" The Minerals, Metals & Materials Society Annual Symposium, San Diego CA, March 1, 2011
116. Gregory N. Parsons "Solar Fuels Materials and Devices using Atomic Layer Deposition" UNC Solar Energy Research Conference, Chapel Hill NC, Jan 14, 2011.

2010

115. Gregory N. Parsons, Jesse S. Jur "Atomic Layer Deposition on Polymers" ECS Annual Meeting, Las Vegas NV, October, 2010.
114. Gregory Parsons and Jess Jur "ALD at Atmospheric Pressure in a Flow-Tube Reactor" Baltic ALD/German ALD Conference, Hamburg, Germany, Sept 16, 2010
113. Gregory N. Parsons "Reactions during inorganic ALD on polymer fibers" Telluride Conference on Semiconductor Surfaces and Processes, July 2010.
112. Gregory N. Parsons "Molecular layer deposition of hybrid organic-inorganic films" Telluride Conference on Semiconductor Surfaces and Processes, July 2010.
111. Gregory N. Parsons "Thin Film Fundamentals and Emerging Applications" MeadWestVaco, Raleigh NC, May 5, 2010.
110. Jess Jur and Gregory Parsons " Nanotechnology -- Yesterday vs. Today vs. Tomorrow", North Carolina Nanotechnology Commercialization Conference, Greensboro NC March 31, 2010

2009

109. Gregory N. Parsons "Atomic Layer Deposition and Nano-Engineered Surfaces" NC State College of Engineering Seminar on Advanced Materials and Manufacturing, Raleigh November 16, 2009.

108. Gregory N. Parsons "Modulation of Surface Wetting Phenomena on Fibrous Materials Using Atomic Layer Deposition" Dept. of Physics, James Madison University, Harrisonburg VA October 29, 2009.
 107. Gregory N. Parsons, "Nanostructured Materials for Renewable Energy" 2009 US Dept of Energy Nanomanufacturing Review Meeting, Washington DC, Sept 15, 2009.
 106. Gregory N. Parsons "Atomic Layer Deposition on Fiber Systems" 2009 International Atomic Layer Deposition Conference, Monterey CA, July, 2009.
- 2008**
105. Gregory N. Parsons "Chemistry and Applications of Low Temperature Atomic Layer Deposition" Dept. of Materials Science, University of Texas at Dallas, Richardson TX, November 7, 2008
 104. Gregory N. Parsons "Chemistry and Applications of Low Temperature Atomic Layer Deposition" Dept. of Chemical Engineering, Colorado School of Mines, Golden Colorado, October 3, 2008
 103. Gregory N. Parsons "Chemistry and Applications of Low Temperature Atomic Layer Deposition" German ALD Conference, GerALD, Sept. 22, 2008, Halle, Germany.
 102. Gregory N. Parsons "Chemistry and Applications of Low Temperature Atomic Layer Deposition" Dept. of Chemistry, University of Delaware, Sept 3, 2008
 101. Gregory N. Parsons "Integrated Fiber Systems, Scientific Challenges and Approach Chemistry" Oak Ridge National Laboratory, Oak Ridge, TN, June 10, 2008.
 100. Gregory N. Parsons "Fiber and Textile Surface Modification & Engineering" ACIMIT, Milan Italy, February 25, 2008.
 99. Gregory N. Parsons "3D Surface Engineering of Bio/Organic Fiber Systems using Atomic Layer Deposition" University of Wisconsin, Madison, Materials Science Program, Madison, Wisconsin, February 7, 2008
 98. Gregory N. Parsons "Atomic Layer Deposition for 3D Nano-Templating of Fiber and Textile Systems" Luna Innovations, Inc. Danville VA, January 18, 2008
 97. Gregory N. Parsons "Atomic Layer Deposition Processes for Advanced Fiber and Textile Systems" Natick Army Soldier Systems Center, Natick, MA January 10, 2008
- 2007**
96. Gregory N. Parsons "Nanotechnology Research at NC State University" Samsung Electronics, Suweon, Korea, Oct 31, 2007.
 95. Gregory N. Parsons, Qing Peng, Jeong-Seok Na, G. Kevin Hyde, Xiao-Yu Sun, Joseph C. Spagnola, S. Michael Stewart, Ryan M VanGundy, Jennifer Ayres, Kusum L. Chandra, Richard J. Spontak, and Christopher B. Gorman, "Advanced Applications for Low-Temperature Atomic Layer Deposition" American Chemical Society Meeting, Boston MA, Aug 2007.
 94. Gregory N. Parsons, Jeong-Seok Na, G. Kevin Hyde, S. Michael Stewart, Qing Peng, Ryan M VanGundy, Jennifer Ayres, Kusum L. Chandra, and Christopher B. Gorman, "Advanced Applications for Low-Temperature Atomic Layer Deposition" Atomic Layer Deposition Meeting, Seoul, Korea, May 18, 2007.
 93. Gregory N. Parsons, "Interface Reactions for ALD of High Work Function Metals and High-k Dielectrics" Samsung, Seoul, Korea, May 17, 2007.
 92. Gregory N. Parsons, "Engineering with Electronically Active Molecules" Rutgers University, Department of Chemistry and Physics, New Brunswick NJ, April 19, 2007.

91. Gregory N. Parsons, "Engineering with Electronically Active Molecules" NC State University, Physics Department, Raleigh NC, Jan 29, 2007.
90. Gregory N. Parsons, "Engineering with Electronically Active Molecules" University of Alabama, Chemical Engineering Department, Tuscaloosa AL, Jan 25, 2007.

2006

89. Joe Spagnola and Gregory N. Parsons, "Carbon Nanotube Integration for Interconnect Applications" SRC Review Meeting, Stanford University, San Jose CA, Aug 25, 2006.
88. Gregory N. Parsons, "Hierarchical Assembly of Single Molecule/Metal Junctions, and Temperature Dependent Characterization" Telluride Semiconductor Surface Chemistry Conference, Telluride CO, Aug 3, 2006.
87. Gregory N. Parsons, "Chemistry of Ruthenium ALD Integrated with Organic Monolayers" Telluride Semiconductor Surface Chemistry Conference, Telluride CO, Aug 1, 2006.
86. Gregory N. Parsons, "Stability of Low Temperature Thin Film Transistors on Plastic Substrates" Samsung, Seoul, Korea, July 28, 2006.
85. Gregory N. Parsons, Kie Jin Park, and S. Michael Stewart "Understanding the Process Window in Oxygen-Based Noble Metal Atomic Layer Deposition" 2006 Atomic Layer Deposition Conference, Seoul, Korea, July 25, 2006.
84. J.C. Spagnola and G.N. Parsons "Carbon Nanotube Lateral Alignment on Nanoscale Electrodes" Semiconductor Research Corp., RTP NC May 8, 2006.
83. G.N. Parsons "Interface Formation Reactions in Inorganic and Organic Electronics" Departmental Seminar, University of Colorado, Boulder CO, Jan 24, 2006.

2005

82. G.N. Parsons, D.B. Terry, K.J. Park "PMOS Gate Metals by Atomic Layer Deposition" SRC Project Review, Raleigh NC Nov 7, 2005.
81. G.N. Parsons "Materials and Interfaces for Improved Low Temperature OLED Barriers" Dow Corning, Midland Michigan, October 2005.
80. G.N. Parsons "Atomic Layer Deposition of High Workfunction Metals for PMOS Gate Electrode Applications" University of Tokyo, Tokyo Japan, Sept. 12, 2005.
79. G.N. Parsons "Atomic Layer Deposition of High Workfunction Metals for PMOS Gate Electrode Applications" SSDM Meeting, Kobe Japan, Sept. 15, 2005.
78. G.N. Parsons "Batch and Alternating Layer Deposition of Metal and Metal Oxide films from Precursors in sc-CO₂ Solution" Micell Inc, April 11, 2005.
77. G.N. Parsons "A Biomimetic Self Assembled Solar Cell" DARPA Nanopower Meeting, Washington DC March. 2005.
76. G.N. Parsons "ALD Metals and reactions at metal/dielectric interfaces" Gate Stack Working Group, Austin Texas, Feb 14, 2005.
75. G.N. Parsons, "Organic/Inorganic Materials for Transistor Devices" Samsung Electronics, Seoul, Korea Feb 3, 2005.
74. G.N. Parsons, K.J. Park, J.M. Doub, M.J. Kelly, and T. Gougousi "Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning" SEMICON Korea, Seoul, Korea Feb 2, 2005.

73. G.N. Parsons “Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning” Hanyang University, Seoul, Korea Feb 1, 2005.
 72. G.N. Parsons “Research in Thin Film Electronic Materials” MCNC RTP NC Jan 5, 2005.
- 2004**
71. G. N. Parsons “*Ru Atomic Layer Deposition and Work function tuning for Advanced Gate Electrodes*” Semiconductor Research Corporation Annual Review, Raleigh NC November 2004.
 70. G. N. Parsons “*Selective Area Ru Atomic Layer Deposition for Advanced Gate Electrodes*” International Atomic Layer Deposition Conference, Helsinki Finland, Aug 16-18, 2004.
 69. G. N. Parsons and T. Gougousi, “*Metal and Oxide Deposition by Solvent Enhanced Chemical Fluid Deposition*” STC Industry Advisors Meeting, Chapel Hill NC April 15, 2004.
 68. G. N. Parsons “*Surface Reactions in High-k and Gate Electrode Deposition*” SEMATECH Gate Stack Meeting, Austin, TX March 8, 2004.
- 2003**
67. G. N. Parsons “*Selective Area Ru Deposition for Advanced Gate Electrodes*” Semiconductor Research Corporation Annual Review, Raleigh NC November 18, 2003.
 66. G. N. Parsons “*Activity in Organic Photovoltaics*” Dupont Central Research, November 6, 2003.
 65. G.N. Parsons “*In-Situ Studies during Atomic Layer Deposition*” Advanced Metallization Conference, Montreal Canada, October 20, 2003.
 64. G.N. Parsons “*Stability of High-k Dielectrics*” SEMATECH Gate Stack Meeting, Austin, TX May 2003.
 63. G.N. Parsons “*Hybrid Silicon/Molecular Electronics*” APS March Meeting, Austin Texas, March 2003.
- 2002**
62. G. N. Parsons “*Applications of Atomic Layer Deposition to High-k Dielectrics*” ALD Conference 2002, Seoul Korea, September 2002.
 61. G.N. Parsons “*Surface Reactions in Silicon and High-k Thin Film Deposition*” Semiconductor Surface Chemistry Conference, Telluride Colorado, July 29, 2002.
 60. Bruce Gnade, University of North Texas, Tayo Akinwande, Massachusetts Institute of Technology, Gregory Parsons, North Carolina State University, Sigurd Wagner, Princeton University, R. Shashidhar, Naval Research Laboratory “*Active Devices on Fiber: The Building Blocks for Electronic Textiles*” International Interactive Textiles for the Warrior Conference, Natick Soldier Systems Center, Natick MA July 2002
 59. S. Stemmer¹, D. Klenov¹, Z. Chen¹, J.-P. Maria², A. I. Kingon², D. Niu³, G. N. Parsons³, “*Electron Energy-Loss Spectroscopy of Alternative Gate Dielectric Stacks*” ¹Department of Mechanical Engineering and Materials Science, Rice University, ²Department of Materials Science and Engineering, North Carolina State University, ³Department of Chemical Engineering, North Carolina State University. Microscopy and Microanalysis Conference, 2002
 58. G. N. Parsons “Engineering Challenges in Molecular Electronics” Dow Chemical, RTP NC, May 13, 2002.
 57. G. N. Parsons “Kinetics of Low Temperature Silicon Plasma Deposition” Eindhoven Technische Universiteit, Eindhoven, The Netherlands, January 14 2002.

56. G. N. Parsons "Silicon/High-k Interface Reactions" IMEC, Leuven Belgium, January 15 2002.
- 2001**
55. G. N. Parsons "Silicon/High-k Interface Reactions" SEMATECH Gate Stack Meeting, Raleigh NC, Nov 8 2001.
54. G. N. Parsons "Silicon/High-k Interface Reactions" Motorola APRDL, Austin TX, October 19, 2001.
53. G. N. Parsons "Silicon/High-k Interface Reactions" University of North Texas, Denton TX, October 18, 2001.
52. G. N. Parsons "Silicon/High-k Interface Reactions" Texas Instruments, Dallas TX, October 17, 2001.
51. G. N. Parsons "Silicon/High-k Interface Reactions" International Workshop on Device Technology, Porto Alegre Brazil, Sept. 5 2001.
50. G. N. Parsons, J. Hauser, V. Misra, D. Feldheim, C. Grant, D. Bocian "Hybrid Silicon/Molecular Electronics Processing" NSF Nanoscale Science and Engineering Centers Reverse Site Visit, Washington DC, May 30 2001.
49. G. N. Parsons "Kinetics of Interface Reactions During High-k Deposition on Silicon" SEMATECH Gate Stack Meeting, Austin TX, May 22 2001.
48. G. N. Parsons "Kinetics of Interface Reactions During High-k Deposition on Silicon" American Physical Society March Meeting, Seattle Washington, March 2001.
- 2000**
47. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" Torrex Corporation, Santa Clara CA, November 2000.
46. G. N. Parsons "Advanced Interfacial Layers" Semiconductor Research Corporation Annual Review, Raleigh NC November 2000.
45. G. N. Parsons "Molecular and Nanoparticle Electronics" National Nanofabrication Users Network Interest Meeting, Raleigh NC, November 2, 2000.
44. G. N. Parsons "Nanotechnology and Nanoelectronics" NASA IAC Meeting, Hillsborough, NC Sept 19, 2000
43. G. N. Parsons "Issues in Advanced Gate Stacks" LSI Logic, Santa Clara, CA July 31, 2000
42. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" IBM TJ Watson Research Center, Yorktown Heights, NY July 12, 2000.
41. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" Lucent Bell Laboratories, Murray Hill NJ, July 11, 2000.
40. G. N. Parsons "Effect of Oxide and Nitride Interface Layers on Si Consumption Reactions During High-k Metal Oxide Deposition on Si" SEMATECH Gate Stack Working Group Meeting, Austin TX, June 2000.
39. G. N. Parsons "Formation of Yttrium silicate on Silicon" Materials Research Society High-k Workshop, New Orleans LA, June 2000.
38. G. N. Parsons "Biocompatible electronic surfaces" ECE Nano-technology Seminar Series, NC State University, May 2000.
37. G. N. Parsons "Formation of Yttrium silicate on Silicon" Symyx Technologies Inc., Santa Clara California, April 2000.

36. G.N. Parsons "Low Temperature Amorphous Silicon – Surface Reactions and Novel Applications" Ecole Polytechnique, Paris France, April 2000.
- 1999**
35. G.N. Parsons "Very low temperature plasma enhanced deposition of electronic insulating thin films", Materials Research Society Spring Meeting, San Francisco, Mar. 2000.
 34. G. N. Parsons "Interface formation reactions in high-k metal oxide deposition on silicon" SRC Program Review, Raleigh NC Nov. 1999.
 33. G. N. Parsons "Surface Reactions in Very Low Temperature (<150°C) Hydrogenated Amorphous Silicon Deposition, and Applications to Thin Film Transistors" International Conference on Amorphous and Microcrystalline Semiconductors, Snowbird UT, Aug. 1999.
 32. J. Crowley and G. N. Parsons "Progress in Low Temperature Materials for TFT's, and Future Display Research" Biannual TFT Workshop, San Jose CA, May 21, 1999.
 31. G.N. Parsons "Low temperature plasma deposition of silicon" First Annual NSF CAREER PI Meeting, Washington DC, January 1999.
- 1998**
30. T.M. Klein and G. N. Parsons "Triode PECVD of Tantalum Pentoxide and Aluminum Oxide thin films", SRC Program Review, Raleigh NC, November 1998.
 29. G. N. Parsons "Low Temperature Silicon Crystallization" Dept. of Physics Seminar, UNC Charlotte, Charlotte NC, Sept. 1998
 28. G.N. Parsons "Surface Reactions in Low Temperature Silicon Deposition: Theory and Experiment" Telluride Surface Chemistry Conference, Telluride CO, August 1998.
 27. G. N. Parsons, "Chemical Processes for Low Temperature Electronic Materials", DARPA Information Exchange Conference, Washington D.C., March 23, 1998.
- 1997**
26. G. N. Parsons, "Low Temperature TFT's on Plastic", DARPA/EPRI Workshop, Dayton Ohio, December 11, 1997.
 25. G. N. Parsons, "Silicon Thin Film Deposition Reactions for Large Area Electronics on Plastics", Chemical Engineering Dept. Seminar, Cornell University, Sept 15, 1997.
 24. G. N. Parsons, "Thin Film Materials for Bistatic Micro-Mechanical Smart Systems and Displays" Dept. of Materials Science and Engineering, NC State University, Sept. 24, 1997
 23. G. N. Parsons, "Real-time process sensing and analysis for plasma deposition" Novellus Inc., San Jose CA, Oct. 22, 1997.
 22. C. S. Yang, C. A. Arthur, W. W. Read, E. Srinivasan, and G. N. Parsons, "Self-Aligned and Full-Self-Aligned Thin Film Transistors (TFT's) Using Plasma Enhanced Selective Area Deposition of In-Situ Doped Microcrystalline Silicon," poster presentation for NSF ERC Review, June 1997.
 21. G.N. Parsons, "Real time sensing and analysis of plasma deposition processes" Novellus Corp., San Jose, CA, October 1997.
 20. G.N. Parsons "Thin Film Materials for Bistatic Micro-Mechanical Smart Systems and Displays" Dept. of Materials Science and Engineering, NC State University, Sept. 24, 1997.
 19. G.N. Parsons "Silicon Thin Film Deposition Reactions for Large Area Electronics on Plastics" Dept. of Chemical Engineering, Cornell University, Sept. 15, 1997.

18. G.N.Parsons "Reaction sensing and analysis for electronic materials on plastic substrates" Becton Dickenson Research Center, Research Triangle Park, NC, June 3, 1997.
 17. G.N. Parsons "Full Self Aligned TFT Processes for AMLCD's" American Vacuum Society Southeast Regional Conference, Oak Ridge Tenn, May 1997.
 16. E. Srinivasan and G.N. Parsons "Plasma enhanced chemical vapor deposition of amorphous and microcrystalline silicon for thin film transistor applications" at Lawrence Livermore National Laboratory, CA, April 1997.
 15. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Xerox PARC, Palo Alto, CA, March 1997.
 14. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Lawrence Livermore National Laboratory, Livermore, CA, March 1997.
 13. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Silicon Light Machines, Inc., Sunnyvale, CA, March 1997.
 12. G.N. Parsons "Manufacturable High Performance TFT's" at DARPA IEC, March 1997.
 11. G.N. Parsons "Progress on TFT fabrication" at DARPA/EPRI Workshop, Palo Alto, CA, January 1997.
- 1996**
10. G.N. Parsons "Interface and Heterostructure Formation for Thin Film Transistor Applications" at NC State/Univ. of Berlin joint workshop, Raleigh, Dec. 9, 1996.
 9. G.N. Parsons "Very Low Temperature Inorganic Thin Film Deposition Compatible with Polymeric Substrates" at the NCSU/Hoechst Celanese Polymer Workshop, Nov. 1996.
 8. G.N.Parsons, "Selective Deposition of Silicon" Materials Research Society Spring Meeting San Francisco, CA, April 10, 1996
 7. G.N. Parsons "Progress toward High Performance TFT's" DARPA/EPRI Workshop, Washington DC, April 15, 1996
 6. G.N. Parsons "Progress Toward Manufacturable High Performance TFT's" DARPA Information Exchange Conference Washington DC, April 17, 1996
- 1995**
5. G.N. Parsons "Controlled Surface Chemistry in Plasma CVD: Applications to High Performance Thin Film Electronics" Dept. of Physics, University of North Carolina Chapel Hill, March 1995
 4. G.N. Parsons "Controlled Surface Chemistry in Plasma CVD: Applications to High Performance Thin Film Electronics" Dept. of Materials Science and Engineering, N.C.State University, Feb. 1995
- 1994**
3. G.N. Parsons, "Selective Microcrystalline Silicon Deposition for TFT/LCD Applications" Materials Research Society Fall Meeting, Boston MA, Nov. 1994.
 2. G.N. Parsons, "Thin Film Transistor Requirements For High Performance Active Matrix Liquid Crystal Displays" Energy Conversion Devices Inc, Troy MI, November 1994.
- 1991**
1. G.N. Parsons "Selected Area Nucleation and Bond Strain Relaxation in Silicon PECVD Using Time Modulated Silane Flow" Symposium for Dry Processing, Tokyo Japan, October 1991.

Technology Licensing and Transfer

2010 – VaporPulse Technologies
2008 – 2010 Alditri Technologies
2006 SolarAmp

Current Research Projects

1. Surface Adsorption and Spectroscopic Analysis Instrument Suite for Synthesis of Novel Catalytic Metal-Organic Framework Thin Films
US Army – Army Research Office (DURIP), 5/2017 – 10/2018
This project seeks to substantively expand the scientific equipment at NC State to create, synthesize and characterize adsorptive and reactive thin film MOF materials, and educate research students in the field of chemically reactive surfaces.
2. Innovative Materials for Microwave Tubes, Phase II and Phase II Option
US DoE, STTR with Calabazas Creek Research Inc., 3/2016 – 3/2019
Develop new tools to enable corrosion protection coatings to be integrated into microwave tubes.
3. Functional and Reactive Surfaces Enabled by ALD
US Army – Army Research Office, 6/2013 – 6/2019
This project addresses the need for new approaches to form conformal and high quality metal organic frameworks (MOF) thin film.
4. Multi-Modal Energy Flow at Atomically Engineered Interfaces
US Army – Army Research Office (with J. Maria and D. Brenner), 7/2016 – 7/2019
Explore fundamental physics and chemistry of shock-induced energy transfer at the nanoscale in organic/inorganic interfaces.
5. Intrinsically Microporous Nonwovens
The Nonwovens Institute, 1/2017 – 12/2019 (with S. Khan)
This project will explore polymers of intrinsic microporosity (PIMs) as a new class of high surface area nonwovens (exceeding 500 m²/g), where the backbone of the starting spun-melt polymer provides intrinsic microporosity (i.e. pores < 2 nm) directly within the nonwoven fiber, without the need for porous additives.
6. Ultra Barriers on Flexible Polymer Based Packaging Materials for Stabilizing Combat Rations by Atomic Layer Deposition
US Army, Natick Soldier Systems Center, 4/2016 – 1/2020
We are working to define metrics and fabrication options for barrier coatings by atomic layer deposition for food packaging required by the US Army.
7. Orthogonal Dielectric/Metal Selective Area Atomic Layer Deposition
Semiconductor Research Corp., 2/2017 – 1/2020
The main goal of our work is to advance fundamental understanding of selective nucleation. We will characterize unwanted surface products and understand how to avoid and/or remove them while expanding selective growth.
8. Advanced Metal Thin Film Nucleation During Atomic Layer Deposition
NSF (with E. Santiso) 7/2017 – 6/2020
The overall goal of this project is to expand fundamental understanding of vapor/surface chemical reaction mechanisms leading to new nanoscale elemental metal, semimetal and metalloid thin films by thermal atomic layer deposition (ALD).
9. Nucleation and Growth PEDOT Thin Films for Capacitor Device Systems
Center for Dielectrics and Piezoelectrics (with E. Dickey) 7/2018 – 6/2020

The overall program goal is to evaluate nucleation and growth of poly(3,4-ethylenedioxythiophene) (PEDOT) via oxidative Molecular Layer Deposition (oMLD) as a route to improve all-solid-state, high-surface-area, mesoporous electrolytic capacitors.

10. Smartphone-Based Leaf Volatile Profiling for Noninvasive Diagnosis of Plant Pathogens
USDA (with Q. Wei) 3/2019 – 3/2021

This project is expected to provide an economically vital, field-deployable, and noninvasive solution for early diagnosis of various important plant diseases or monitoring of abiotic stresses with a high degree of detection sensitivity and specificity.

11. Area-Selective Initiated-Molecular Layer Deposition of Polymers
Semiconductor Research Corp. 1/2019 – 12/2021

The main goal of our work will be to advance fundamental understanding of nucleation and area-selectivity during vapor-phase nucleation and deposition of polymers.

12. Phase II IUCRC North Carolina State University: Center for Dielectrics and Piezoelectrics
NSF 3/2019 – 2/2024

This internationally-recognized research center is dedicated to improving the science and technology of dielectric and piezoelectric materials and their integration into components/devices.

Pending Research Projects

1. Atomic and Molecular Layer Deposition for Capacitor Device Systems

Private Industry

We propose to understand, develop and demonstrate atomic layer deposition, ALD, and molecular layer deposition, MLD techniques for creation of thin film materials for advanced capacitor applications and related systems of interest to the sponsor.

2. Reactive Porous Surfaces, Thin Films and Fibers

US Army – Army Research Office

This project's objective is to advance understanding of synthesis and functional performance of metal-organic framework and related materials integrated with fibrous and polymer platforms of interest to DoD. Primary focus is on active and passive protection from chemical warfare agent exposure.

Research Facilities

Parsons' lab occupies approximately 2400 ft² in the Department of Chemical and Biomolecular Engineering in three lab rooms in Engineering Building I (opened January 2005) on NC State's Centennial Campus. The labs have four 6-foot chemical hoods, two 6-foot walk-in hoods, and 7 ventilated gas bottle cabinets. Available equipment includes:

Analytical equipment:

- Quantachrome Autosorb-1C for Brunauer-Emmett-Teller (BET) surface area, pore size distribution, and gas nitrogen adsorption/desorption analysis
- Micromeritics 3 Flex surface characterization and smart vac prep
- Q2000 Differential scanning CA with liquid nitrogen cooling
- Leica GZ6T crystal probe
- Ramé-Hart Contact Angle Goniometer
- Digital Instruments D3000 AFM (equipped with conducting probe capability)
- Nicolet Evolution 300 UV-Vis Spectrophotometer
- Nicolet 6700 FT-IR Spectrophotometer (with near- and far-IR detectors)
- Nicolet iso59 FTIR
- SZH10 Olympus Stereoscope
- BX-51 Olympus Microscope (5x-100x objectives, transmitted/reflected/Nomarski)
- Olympus BX60
- J.A. Woollam Alpha-SE Spectroscopic Ellipsometer
- Veeco Dektak D-150 Step Profilometer (with 3D profiling accessory)
- On-line Mass Spectrometer x 2

Processing Equipment:

- Linberg/Blue Controlled Atmosphere Tube Furnace
- Laurell Series 400 Spin Processor
- Thermolyne Benchtop Muffle Furnaces (Si oxidation, calcination, atm anneal)
- AX8560 semiconductor grade ozone generator
- Twelve custom-made hot-wall ALD and MLD flow reactors:
 - Two 2.5" diameter Al₂O₃, ZnO, TiO₂ furnace tube systems
 - One 2.5" diameter exploratory tube reactor (various materials)
 - Two large diameter tube systems (TMA, DEZ, TiCl₄)
 - W ALD tube system (WF₆/Si₂H₆), in walk-in hood
 - MLD tube reactor (TMA, DEZ, EG, glycidol, APTES, etc)
 - TiO₂ furnace system (Ti i-propoxide, TDMAT, TiCl₄, etc)
 - Oxide/Organic ALD system, with in situ IR transmission capability
 - Two custom ALD reactors for metal and metal oxides.
- 3 custom modified Maxtek BSH-150 quartz crystal microbalance sensor heads
- Leybold dryvac 50B
- Emitech SC7620 sputter coater
- Thermolyne flow through annealing furnace
- RF generator PFG 300 RF
- Thermolyne tube furnaces 79300 and 79400

Chemical Synthesis Equipment

- Parr Instrument Autoclaves (MAWP 3000 PSI at 350C) x3
- Fisher Isotemp model 828A vacuum oven

- Nexus II integrated glove box with vacuum system
- Benchtop glove box

Electrical, Electrochemical and opto-electrical characterization:

- Janis probe station with controlled temperature (80–450 K) and ambient
- Keithley high impedance ammeter
- Agilent LCR meter (capacitance vs. voltage analysis)
- Newport 91160 solar simulator (150W and 300W)
- Princeton Applied Research Electrochemical Impedance Analyzer
- Several PAR and other cyclic voltammetry systems
- Gamry 36029 potentiostat/galvenostat/ZRA

Equipment in the NC State Analytical Instrument Facility: The Analytical Instrumentation Facility (AIF) enables state-of-the-art research through acquisition, development, maintenance, training, and access to major analytical and materials characterization instrumentation. Facilities currently include:

- FEI Titan G2 80-300 with 5th-order aberration corrector with point-to-point resolution less than 0.07 nm in STEM mode
- FEI Verios monochromatic FESEM/STEM
- FEI Quanta 3D FEG dual-column SEM/FIB
- State of the art TEM sample preparation laboratory
- JSM-7600F Cryo-SEM
- JEOL 2010F S/TEM, for high resolution TEM, ADF-STEM, EELS and EFTEM
- JEOL 2000FX for conventional bright-field/dark-field imaging, with in situ heating and voltage biasing, liquid flow cell stages (Protochips)
- Hysitron Ubi-1 Nanoindenter with in situ SPM imaging
- SPECS XPS/UPS
- ION TOF TOF-SIMS5 Time-of-Flight Secondary Ion Mass Spectrometer (TOF-SIMS)
- PANalytical Empyrean X-ray Diffractometer
- Rigaku SmartLab X-ray Diffractometer
- Bruker AXS General Area Detector Diffraction System (GADDS)
- Bruker Dimension 3000 and MultiMode scanning probe microscopes

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FAVORED TECH CORPORATION,

Petitioner

v.

P2I LTD.,

Patent Owner

Case No. IPR2020-01198

Patent No. 10,421,876

PATENT OWNER'S PRELIMINARY RESPONSE

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Patent Trial and Appeal Board
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, Virginia 22313-1450

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LIST OF EXHIBITS

EXHIBIT NO.	TITLE
1001	U.S. Patent No. 10,421,876
1002	Declaration of Dr. Karen Gleason
1003	Curriculum vitae for Dr. Karen Gleason
1004	International Publication WO 2007/083122, "Novel Products," to Stephen Coulson ("Coulson-122")
1005	International Publication No. WO 99/64662, "Surface Coatings," to Jas Pal Singh Badyal, et al. ("Badyal")
1006	U.S. Patent 2,716,638, "Divinyltetramethyldisiloxane and Polymers Therefrom," to Merrill Cohen and John R. Ladd ("Cohen")
1007	U.S. Patent 3,816,564, "Insulation Coating Compositions," to Harvey Ray Holliday and Gary Lee Schurter ("Holliday")
1008	U.S. Patent Application Publication US 2007/0020451, "Moisture Barrier Coatings," to Raghunath Padiyath and Moses M. David ("Padiyath")
1009	Francesch, L. et al, "Fabrication of Bioactive Surfaces by Plasma Polymerization Techniques Using a Novel Acrylate-Derived Monomer," <i>Plasma Processes and Polymers</i> , 2:605–11 (2005) ("Francesch")
1010	Declaration of Dr. Salvador Borrós Gómez
1011	U.S. Patent 5,804,669, "Preparation of Polymers Comprising Peroxycarboxyl Groups," to Jürgen Tropsch and Jörg Breitenbach ("Tropsch")
1012	International Publication WO 2012/158953, "Coated Electronic Devices and Associated Methods," to Filip Legein, et al.
1013	U.S. Patent Application Publication US 2013/0176700, "Electronic Devices with Internal Moisture Resistant Coatings," to Blake Stevens, et al.
1014	International Publication WO 2014/026967, "Surface Coatings," to Filip Legein, et al.
1015	U.S. Patent Application Publication US 2005/0141738, "Hydrophobic Coating of Individual Components of Hearing Aid Devices," to Erdal Karamuk
1016	U.S. Patent 6,551,950, "Surface Coatings," to Jas P S Badyal, et al.

1017	U.S. Patent 4,562,091, "Use of Plasma Polymerized Organosilicon Films in Fabrication of Lift-Off Masks," to Harbans S. Sachdev and Krishna G. Sachdev
1018	U.S. Patent 7,439,315, "Polymer Film and Method for Producing the Same," to Nobutaka Kunimi, et al.
1019	Coulson, S.R., et al., "Ultralow Surface Energy Plasma Polymer Films," <i>Chemistry of Materials</i> 12(7):2031–2038 (2000)
1020	Declaration of S. Rampersad
1021	U.S. Patent Application Publication US 2010/0203347, "Method for Liquid Proofing an Item by Plasma Graft Polymerisation," to Stephen Coulson (Coulson-347)
1022	International Publication WO 98/58117, "Surface Coatings," to Jas Pal Singh Badyal, et al.
1023	Tarducci, C., et al., "Synthesis of Cross-Linked Ethylene Glycol Dimethacrylate and Cyclic Methacrylic Anhydride Polymer Structures by Pulsed Plasma Deposition," <i>Macromolecules</i> 35(23):8724–8727 (2002)
1024	U.S. Patent 6,214,423, "Method of Forming a Polymer on a Surface," to Wei William Lee, et al.
1025	International Publication WO 2012/168440, "A Coated Substrate Having Hydrophobic Moiety-Repelling Surface Characteristics and Process for Preparing the Same," to Christian Taesler
1026	Yagüe, J.L. and Gleason, K.K., "Enhanced Cross-Linked Density by Annealing on Fluorinated Polymers Synthesized via Initiated Chemical Vapor Deposition to Prevent Surface Reconstruction," <i>Macromolecules</i> 46(16):6548-6554 (2013)
1027	U.S. Patent 6,207,238, "Plasma Enhanced Chemical Deposition for High and/or Low Index of Refraction Polymers," to John D. Affinito
1028	Prosecution history of the '876 patent
1029	Yao, W., et al., "Fluorinated poly(meth)acrylate: Synthesis and properties," <i>Polymer</i> 55(24):6197-6211 (2014)
1030	U.S. Patent Application Publication US 2013/0135936, "Gas Barrier Base Material and Gas Barrier Laminate," to Takeshi Morozumi, et al.
1031	U.S. Patent Application Publication US 2011/0148979, "Curable Phase Change Inks," to Marcel P. Breton, et al.

1032	Sartomer Company Material Safety Data Sheet, Product CD406, dated June 9, 2005
1033	U.S. Patent Application Publication US2005/0034667, "Method and Apparatus for Forming Silicon-Containing Insulation Film Having Low Dielectric Constant," to Naoto Tsuji, et al.
1034	Yasuda, H., <i>Plasma Polymerization</i> , 1985 Academic Press, London (Excerpts)
1035	Kurosawa, S., et al., "Detection of deposition rate of plasmopolymerized acrylate and methacrylate derivatives using quartz crystal microbalance," <i>Thin Solid Films</i> 457:26-33 (2004)
1036	Kurosawa, S., et al., "Detection of deposition rate of plasmopolymerized silicon-containing films by quartz crystal microbalance," <i>Thin Solid Films</i> 407:1-6 (2002)
1037	Joback, K.G. and Reid, R.C., "Estimation of Pure-Component Properties from Group-Contributions," <i>Chem. Eng. Comm.</i> 57:233- 243 (1987)
1038	U.S. Patent Application Publication US 2006/0122301, "Fluorinated divinyl ethers," to Haridasan K. Nair and David Nalewajek
1039	Chemical information obtained from chemspider.com
2001	Declaration of Gregory Parsons, Ph.D.
2002	Yasuda, H., <i>Plasma Polymerization</i> , Academic Press, London 1985 (Excerpt)
2003	Guimond, Sebastien et al., "Influence of gas phase and surface reactions on plasma polymerization," <i>Surface & Coatings Technology</i> 205:S447-S450 (2011)

I. INTRODUCTION

Patent owner P2i respectfully submits this Preliminary Response to Favored's Petition. This Preliminary Response is supported by the declaration of P2i's retained expert, Dr. Gregory Parsons (Ex. 2001), as well as other accompanying exhibits.

Petitioner falls far short of its burden of proving that *inter partes* review of the challenged claims of U.S. Pat. No. 10,421,876 (the '876 patent) is warranted under the asserted grounds. 37 C.F.R. § 42.108(c). The '876 patent discloses and claims an electronic or electrical device or component thereof having a protective cross-linked polymeric coating obtained by exposing the device to a plasma comprising a novel combination of monomers and crosslinking reagents. The Petition relies extensively on hindsight for its five redundant obviousness grounds. The asserted grounds piece together two primary references whose actual teachings Petitioner distorts, and secondary references that have nothing to do with forming plasma-derived, cross-linked polymer protective coatings for electronic devices.

Petitioner's assertion that the claims do nothing more than recite "a jumble of crosslinkers" that the examiner had erroneously concluded were "absent from the prior art" (Pet. at 22) highlights the factual and legal flaws that permeate its entire obviousness analysis. The claims as a whole are not directed to crosslinkers per se, but to electronic devices coated using a uniquely formulated plasma that overcomes prior challenges associated with forming protective coatings suitable for electronic

devices and improves certain desired properties of such coatings. Rather than demonstrating that it would have been obvious to use the claimed synergistic combination of compounds to provide improved plasma polymerized protective coatings for electronics, the Petition does little more than show that the recited monomers and crosslinking compounds were separately known in the polymer chemistry art in general. The law is clear, however, that “a patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.” *Tinnus Enterprises, LLC v. Telebrands Corp.*, 846 F.3d 1190, 1207 (Fed. Cir. 2017) (citing *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007)).

Neither of the primary Coulson-122 or Badyal references discloses a plasma deposition process that combines any of the claimed monomers with any of the claimed crosslinking reagents, and the five secondary references disclose polymerization processes that have no relevance to the ’876 patent claims. Petitioner’s arguments fail to address the references’ teachings as a whole, while incorrectly assuming that the relevant plasma deposition technology is “routine” and that plasma precursor formulation involves nothing more than substituting “known elements with each performing its known and expected function.” (See *e.g.*, Pet. at 38.) In reality, the effects of altering the chemical composition of such plasma precursors on the resulting coating properties is highly unpredictable. The Petition

makes no showing that any of the asserted references, alone or in combination, would have provided useful guidance to a person of ordinary skill in the art (“POSA”) who was attempting to improve plasma-deposited protective coatings for electronics.

The asserted grounds fail to present any evidence that establishes that the Patent Office erred in granting the ’876 patent. The obviousness grounds fail because there is no evidence demonstrating or even suggesting that a POSA would have been motivated at the time of the invention to combine aspects of the disparate asserted references in the hindsight-driven manner now proposed by Petitioner, or that a POSA would have had a reasonable expectation of success in doing so.

Because the Petition does not show that at least one claim is reasonably likely to be invalid, institution should be denied. 35 U.S.C. § 314.

II. BACKGROUND

A. The ’876 Patent

The ’876 patent discloses and claims an electronic or electrical device (or electronic or electrical component thereof) having a novel protective coating obtained by exposing the device to a plasma comprising a particular monomer compound and particular crosslinking reagent. The inventors encountered difficulties in obtaining plasma-derived protective coatings suitable for electronic devices, such as mobile phones. Such coatings must be highly hydrophobic yet

stable, tack-free, and resistant to smearing. (Ex. 1001 at 1:20–2:6.) In particular, applying lower powers to the monomer 1H, 1H, 2H, 2H-perfluorooctyl acrylate (PFAC6) to form a plasma resulted in a more hydrophobic (i.e., water resistant) coating, but the coating was unstable in the presence of water and was tacky and easily smeared. (*Id.* at 1:34–56.) Applying higher powers resulted in coatings that were more crosslinked and resistant to smearing, but this process change decreased the hydrophobicity of the coating. (*Id.* at 1:47–67, 16:4–10, FIGS. 1 and 2.) Accordingly, the inventors recognized that the process conditions required for producing tack and smudge-free protective coatings for electronic devices were quite limited and caused the coatings to lack sufficient hydrophobicity. (*Id.* at 2:1–6.)

The inventors unexpectedly discovered that they could obtain improved protective nanoscale coatings, and also increase the range of suitable plasma processing conditions, by adding particular crosslinking reagents to the monomer introduced during the plasma polymerization process. (*Id.* at 2:49–55.) The '876 patent specification discloses that low energy pulsed plasma processing of certain combinations of monomers and crosslinking compounds resulted in co-polymer protective coatings that exhibited improved hydrophobicity while remaining tack and smudge-free. (*Id.* at 2:56–64, 16:58–17:19, compare FIGS. 2 and 4.)

In addition, the inventors discovered that the inventive coatings, particularly when thicker than 50 nm, act as physical barrier coatings, which provide a barrier to

mass and electron transport and restrict diffusion of water, oxygen, and ions. (*Id.* at 3:3–11.) Such coatings are quite advantageous for protecting electronic devices like mobile phones as well as printed circuit boards, semi-conductor chips, and other internal electronic components thereof. (*Id.* at 1:5–13, 14:30–58.) These barrier coatings are electrically insulating while remaining sufficiently compliant to allow electrical connections to be made to the device, e.g., to allow the device to be connected to a charging cable. (*Id.* at 3:41-54; Ex. 2001 ¶ 48.) The specification teaches that such barrier coatings can achieve an electrical resistance of at least 1×10^7 Ohms and sufficient water resistance to allow the coated device to be submerged in water of up to 1m in depth for 30 minutes while powered on, characteristics required to pass industry standard “IPX7 test.” (Ex. 1001 at 3:55–4:6.) The resulting barrier coatings were also significantly more electrically resistant than coatings formed without the identified crosslinking reagents. (*Id.* at 16:46–54, FIG. 5, 18:10–23, showing increase in resistance from 2.1×10^7 to 9.2×10^9 Ohms when 10% DVA crosslinker added to PFAC6 monomer plasma.)

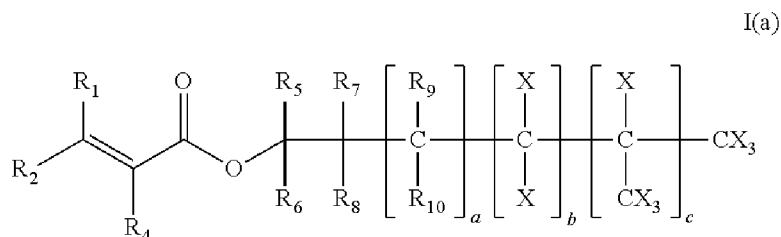
Claim 1 specifies:

An electronic or electrical device or electronic or electrical component thereof comprising a protective cross-linked polymeric coating on a surface of said device or component;

wherein the protective cross-linked polymeric coating is obtained by exposing said device or component to a plasma comprising

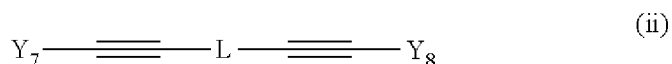
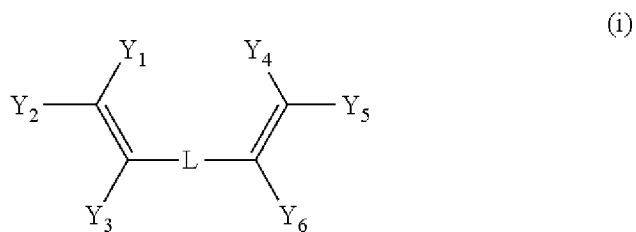
a monomer compound and a crosslinking reagent for a period of time sufficient to allow formation of the protective cross-linked polymeric coating on a surface thereof,

wherein the monomer compound is a compound of formula I(a):



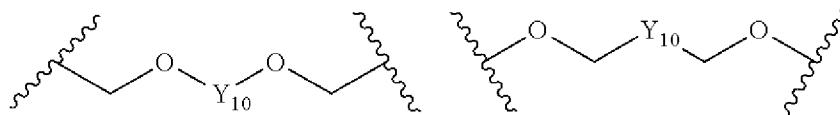
wherein each of R₁, R₂, R₄ and R₅ to R₁₀ is independently selected from hydrogen or an optionally substituted C₁-C₆ branched or straight chain alkyl group; each X is independently hydrogen or halogen; a is from 0-10; b is from 3 to 7; and c is 0 or 1;

and wherein the crosslinking reagent comprises two or more unsaturated bonds attached by means of one or more linker moieties and has a boiling point of less than 500° C. at standard pressure, the crosslinking reagent having one of the following structures:



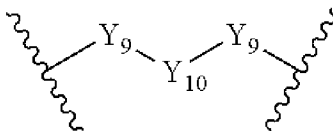
where Y₁, Y₂, Y₃, Y₄, Y₅, Y₆, Y₇ and Y₈ are each independently selected from hydrogen, optionally substituted cyclic, branched or straight chain C₁-C₆ alkyl or aryl; and L is a linker moiety;

wherein for compound (i) L is of formula A having one of the following structures:



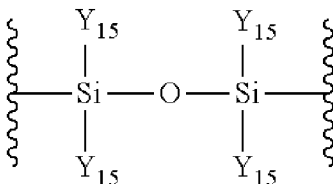
and Y_{10} is selected from optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene and a siloxane group;

or wherein for compound (i) L is of formula B having the following formula:



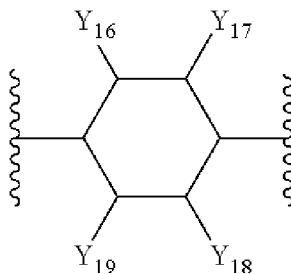
where each Y_9 is independently selected from, a bond, $-O-$, $-O-C(O)-$, $-C(O)-O-$, $-Y_{11}-O-C(O)-$, $-C(O)-O-Y_{11}-$, $-OY_{11}-$, and $-Y_{11}O-$, where Y_{11} is an optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene; and

wherein Y_{10} has the following formula:



and each Y_{15} is independently selected from optionally substituted branched or straight chain C_1 - C_6 alkyl;

or wherein Y_{10} has the following formula:



and Y₁₆ to Y₁₉ are each independently selected from H and optionally substituted branched or straight chain C₁-C₈ alkyl or alkenyl.

(*Id.* at 18:26–19:57.) The prior art of record shows that the claimed combination of monomers and crosslinking reagents was not previously known, used, or suggested for use in a plasma process to obtain a protective coating suitable for an electronic device.

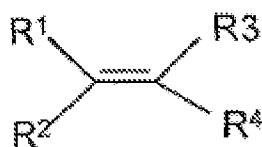
B. The Asserted Prior Art

1. Coulson-122

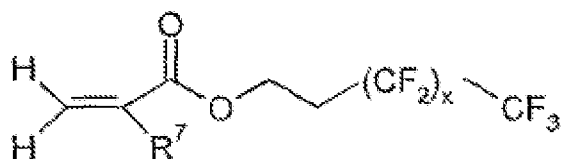
Coulson-122 is a PCT publication filed by P2i describing an earlier invention of Stephen Coulson, the primary inventor of the '876 patent. Coulson-122 discloses an electronic device having a polymeric coating formed by exposing the device to a pulsed plasma composition that includes a monomer selected from a particular group of monomers. (Ex. 1004 at 3:20–34, claim 1.)

Recognizing that plasma polymers had previously been used to coat fabric substrates, Coulson-122 discovered that by utilizing a specific type of monomer under particular deposition conditions, a highly liquid repellent nano-coating could be deposited on an electronic device without affecting the operation of the device. (*Id.* at 2:32–3:18.)

Coulson-122 discloses that the monomer used to form the polymeric coating may have the following general structure:



(*Id.* at 3:20–25.) In a particular example, Coulson-122 discloses a monomer having the following structure:



where R^7 is hydrogen, C_{1-10} alkyl, or C_{1-10} haloalkyl and x is an integer from 1 to 9. (*Id.* at 12:13–21). When R^7 is hydrogen and x is 7, the monomer is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate. (*Id.* at 12:21–22, claims 11 and 28.)

Coulson-122 teaches that a polymeric coating may be formed on an electronic device by exposing the device to a pulsed plasma including the monomer. (*Id.* at 3:20–25.) The device may be exposed to the pulsed plasma for a sufficient period of time to allow a protective polymeric layer to form on the surface of the device. (*Id.* at 3:20–34, 4:1–3.) With regards to plasma polymerization, Coulson-122 warns that “[t]he properties of the resultant coating can depend upon the nature of the substrate as well as the nature of the monomer used and conditions under which it is deposited.” (*Id.* at 3:9–12.)

Coulson-122 is silent regarding the use of a crosslinking reagent in the pulsed plasma. Despite Stephen Coulson being a named inventor of the earlier Badyal reference, Coulson-122 does not teach or suggest forming a polymeric coating using a combination of monomers or a monomer and a crosslinking reagent. (Ex. 1004 at 7:19–24; Ex. 2001 ¶ 58.)

2. Badyal

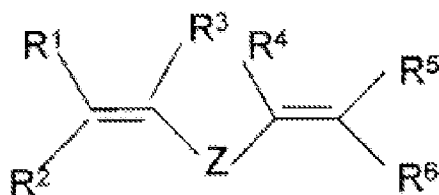
Badyal is a PCT publication describing earlier research directed to making oil and water repellant fabric coatings. This work was performed by Professor Jas Pal Badyal and his coinventors, including Stephen Coulson. (Ex. 1005 at cover page.) Badyal describes a method of coating a surface with a polymer layer which includes exposing the surface to a plasma comprising one or more organic monomeric compounds, at least one of which comprises two double bonds. (*Id.* at 4:4–8.) The method forms a layer of cross-linked polymeric material on the surface to provide a water and oil repellant coating. (*Id.* at 1:3–5, 4:8–9, 6:10–12, 9:18–19.) Badyal does not appreciate or address the unique challenges associated with plasma deposition coatings for electronic devices and electronic components. Although Badyal states that “any solid substrate, such as fabric, metal, glass, ceramics, paper or polymers” may be coated (*id.* at 9:28–30), Badyal focuses in particular on fabric substrates (*id.* at Abstract, 1:14–19, 1:25–2:8, 2:31–3:2, 4:27–29, 9:28–34, 10:1–6, 11:22–24). Badyal discloses that such coatings applied to fabrics have sufficient durability to

withstand washing. (*Id.* at 4:24–29.) Badyal does not disclose that the coatings would be suitable for electronic devices. (Ex. 2001 ¶ 59.) Badyal provides no information that would have led a person of ordinary skill in the art to understand the particular characteristics needed for a suitable coating for electronics devices, the chemistry or processing parameters required to achieve this, or whether any particular crosslinking compounds would be useful for this purpose.

Contrary to Petitioner's assertions, Badyal does not teach that all crosslinking compounds known in the polymer art are suitable for use in Badyal's disclosed plasma deposition process. In this regard, Petitioner fails to consider Badyal's full disclosure and teachings as a whole. To begin with, Badyal is directed solely to plasma polymerization for forming oil and water repellant coatings. The reference does not in any way borrow from or analogize to techniques or compositions deployed in other types of polymerization processes. Indeed, just like Coulson-122, Badyal acknowledges that there are known fundamental differences between plasma deposition techniques and conventional polymerization techniques: “[c]onventional polymer synthesis tends to produce structures containing repeat units which bear a strong resemblance to the monomer species, whereas a polymer network generated using a plasma can be extremely complex.” (Ex. 1005 at 2:20–24.) Badyal also teaches that “[t]he success or otherwise of plasma polymerization depends upon a number of factors, including the nature of the organic compound.” (*Id.* at 2:26–28.)

Badyal introduces his invention as providing a method involving “exposing [a] surface to a plasma comprising one or more organic monomeric compounds, at least one of which comprises two double bonds, so as to form a layer of cross-linked polymer on said surface.” (*Id.* at 4:4–9.) After describing the relevant types of plasmas processes (*id.* at 4:11–15), Badyal teaches that “suitable compounds with more than one carbon-carbon double bond . . . used in the plasma are suitably those which will yield cross-linked polymers having oil or water repellent properties.” (*Id.* at 4:17–21). A POSA would have certainly understood from this that Badyal’s disclosure is focused on crosslinking compounds that are suitable for forming a plasma-polymerized coating having oil or water repellent properties. (Ex. 2001 ¶ 61.)

Badyal describes that suitable crosslinking compounds for his plasma deposition process are of the following general formula (I):

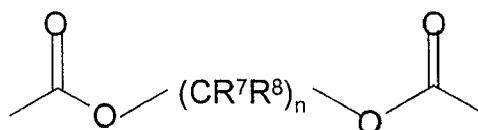


where Z is a particular bridging group. (Ex. 1005 at 5:1–5.) Petitioner repeatedly cites one sentence out of context to argue that Badyal discloses that Z could be any bridging group known in the polymer art. (Pet. at 13, 25, 31, 39.) This is a critical misreading of Badyal. The class of suitable bridging groups Z that Badyal

recommends, in the context of the document as a whole, is far narrower. Properly read in context, what this portion of Badyal actually indicates is that the bridging groups that can be used are known in the art, i.e., the suitable groups are not newly synthesized groups but previously known groups. Badyal then discloses the example suitable bridging groups immediately thereafter:

Examples of suitable bridging groups Z for use in the compound of formula (I) are those known in the polymer art. In particular they include optionally substituted alkyl groups which may be interposed with oxygen atoms. Suitable optional substituents for bridging groups Z include perhaloalkyl groups, in particular perfluoroalkyl groups.

In a particularly preferred embodiment, the bridging group Z includes one or more acyloxy or ester groups. In particular, the bridging group of formula Z is a group of sub- formula (II)

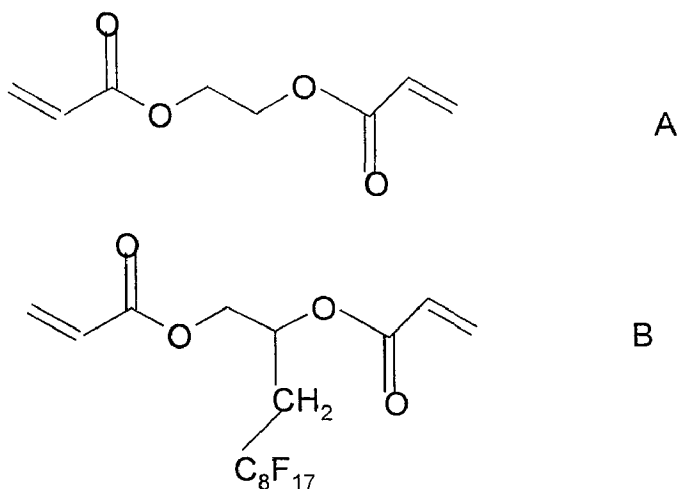


where n is an integer of from 1 to 10, suitably from 1 to 3, each R^7 and R^8 is independently selected from hydrogen, alkyl or haloalkyl.

Suitably R^1 , R^2 , R^3 , R^4 , R^5 , and R^6 are haloalkyl such as fluoroalkyl, or hydrogen. In particular they are all hydrogen.

Suitably the compound of formula (I) contains at least one haloalkyl group, preferably a perhaloalkyl group. This allows the formation oil repellent as well as water repellent coatings. This group is suitably located as a group R^7 or R^8 within the bridging group Z.

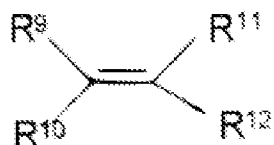
Thus particular examples of compounds of formula (I) include the following:



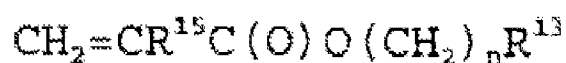
(Ex. 1005 at 5:18–6:20.) Thus, rather than suggesting to a POSA that any bridging group Z known in the polymer art could be used, Badyal teaches that the suitable Z groups are known, and provides detailed guidance regarding the identity of those suitable bridging groups.

None of the bridging groups Z actually disclosed in Badyal correspond to the linker moiety “L” of the crosslinker reagents claimed in the ’876 patent. (Ex. 2001 ¶ 62.) Of the only two specific examples of compounds A and B which satisfy formula (I), neither include the linking groups claimed in the ’876 patent. (*Id.*) Petitioner’s expert, Dr. Gleason, does not argue to the contrary. Accordingly, Badyal does not disclose that the crosslinking compound includes any of the linker moieties claimed in the ’876 patent. (*Id.*)

Badyal describes other monomeric compounds that may be used in combination with the disclosed crosslinking compounds to form the coating, including compounds having the following general formula:



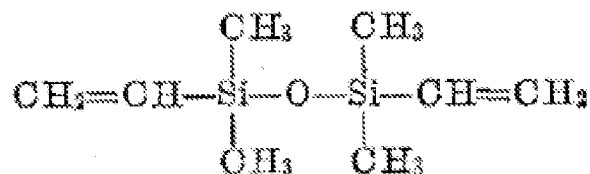
(Ex. 1005 at 7:17–32.) Badyal describes that, in one embodiment, the other monomeric compound may have the following formula:



where R^{13} is an alkyl or haloalkyl group and R^{15} is a hydrogen or C_{1-6} alkyl, such as methyl. (*Id.* at 7:26–27, 9:10–16.) Badyal describes that R^{13} is preferably a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is an integer. (*Id.* at 8:15–18.) When R^{13} is a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is 8 and R^{15} is a hydrogen, the monomeric compound is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate, otherwise known as PFAC8. (Ex. 2001 ¶ 63.)

3. Cohen

Cohen issued as a U.S. patent in 1955 and relates to a then-new monomer divinyltetramethyldisiloxane (DVTMDS or disiloxane) and polymerization products produced therewith. (Ex. 1006 at 1:15–20.) Cohen describes DVTMDS as having the formula:



(*Id.* at 1:27–30.)

Cohen has nothing to do with plasma polymerization processes to form protective coatings for electronic devices. It discloses how to formulate DVTMDS, as well as conventional polymerization processes to form copolymers using DVTMDS. (*Id.* at 1:34–44.) Cohen explains:

For example, the disiloxane with the other copolymerizable material may be dissolved in a suitable inert solvent, for example, an aromatic hydrocarbon solvent (such as benzene, toluene, xylene, etc.) and polymerization of the mixture effected. Another method which may be employed in preparing copolymers the instant claimed invention includes the preparation of an intimate mixture of the monomeric materials by preparing suspensions or emulsions of the disiloxane and the copolymerizable material in a liquid medium as, for example, water.

(*Id.*, *see also* Examples 1 and 2 at 2:70–3:50.) As this passage reflects, Cohen focuses on effecting polymerization in an inert solvent or in an emulsion.

Cohen fails to describe the use of DVTMDS with the specific monomers recited in claim 1 of the '876 patent. (Ex. 2001 ¶ 66.) Indeed, Cohen does not disclose the use of DVTMDS in a plasma polymerization process at all. Nor is Cohen directed to forming protective cross-linked polymeric coatings, whether for an

electronic device or on any other substrate. Cohen discloses instead that copolymers made using DVTMDS may be used as a dielectric material in a capacitor, as well as a cable or electrical coil impregnant, or as a filling compound in potheads and cable joints. (Ex. 1006 at 5:1–21.)

4. Holliday

Holliday is also not pertinent to forming protective coatings in a plasma deposition reactor. This reference relates to curable insulating compositions for “dip coating electrical connectors and other conductors.” (Ex. 1007 at 1:12–15, 1:23–25, 2:16–21, 2:60–64.) In particular, Holliday describes that the compositions are suitable for insulating underground secondary bus connectors used in the utility industry. (*Id.* at 1:52–2:35.) Holliday’s teachings are directed to solving problems associated with liquid polymer compositions for dip coating those types of devices, and not to methods of providing improved plasma deposition processes or nano-scale protective coatings.

Holliday describes various disadvantages with previously known molded, pre-shaped rubber insulating boots and sleeves, plastisol coatings, and thermosetting resin coatings for electrical connectors. (*Id.* at 1:26–51.) For example, molded insulations were expensive and lacked versatility, and plastisol coatings lacked sufficient electrical and heat distortion properties. (*Id.* 1:63–2:16.) To overcome

such disadvantages, Holliday invented a curable composition of polyolefin, polyvinylchloride and a reactive allylic or vinylic monomer. (*Id.* at 2:39–42.)

Holliday discloses that crosslinking allylic or vinylic monomers are employed in these dip coating compositions. (*Id.* at 3:21–54.) Among a list of 52 possible monomers, Holliday includes diallyl-1,4,-cyclohexanedicarboxylate (“DCHD”) a suitable allylic monomer and 1,4-divinyl-oxybutane (also known as 1,4,-butanediol divinyl ether or BDVE) as a suitable vinylic monomer. (*Id.* at 3:34–35, 3:52–53.) The composition is created by “forming an intimate admixture of the polymeric components and the reactive monomer.” (*Id.* at 2:47–50.) A typical curing agent is a high temperature decomposing peroxide. (*Id.* at 2:50–52.) After the liquid composition is applied to a surface of an object, the coating is cured to form a crosslinked insulation layer. (*Id.* at 2:60–68.) The curing step requires heating the coated object to a high temperature, such as about 175 °C for 25 minutes. (*Id.* at 6:31–34.) Alternatively, the coating is cured using irradiation techniques. (*Id.* at 2:68–70.)

Holliday bears no relation to plasma polymerization processes, let alone to plasma polymerization processes used to form protective coatings, whether for electronic devices or otherwise. Further, Holliday fails to describe the use of DCHD or BDVE in combination with the specific monomers recited in claim 1 of the '876 patent. (Ex. 2001 ¶ 70.)

5. Padiyath

Padiyath is entitled “Moisture Barrier Coatings” and relates to multi-layer barrier assemblies for the protection of moisture or oxygen sensitive articles, and particularly organic light emitting diode devices (OLEDs). (Ex. 1008 ¶¶ 2, 5.) The barrier assemblies include alternating diamond-like glass (DLG) layers and polymer layers, which may be crosslinked. (*Id.* ¶¶ 25, 30, 52.) Padiyath discloses two long lists of possible preferred and alternative monomers that can be used to form its polymer layers. (*Id.* ¶¶ 52, 54.) Buried within the list of alternative monomers is cyclohexane dimethanol diacrylate esters. (*Id.* ¶ 54.)

Unlike the claims of the '876 patent, Padiyath does not relate to a plasma deposition process that allows the formation of a protective cross-linked polymeric coating on a surface. Padiyath discloses forming polymer layers used in a multi-layer stack of the barrier assemblies by “crosslinking the layer to form the polymer in situ, e.g., by flash evaporation and vapor deposition of a radiation crosslinkable monomer, followed by crosslinking using, for example, an electron beam apparatus, UV light source, electrical discharge apparatus or other suitable device.” (Ex. 1008 ¶ 61.) Padiyath states that plasma polymerization may be employed only “if it will provide a polymeric layer having a glassy state at an elevated temperature, with a glass transition temperature greater than or equal to that of HSPET.” (*Id.* ¶ 54.) Padiyath describes that “[m]ost preferably, the polymer layers are formed by flash

evaporation and vapor depositing *followed by* crosslinking in situ . . .” (*Id.* ¶ 61 (emphasis added).)

Padiyath fails to disclose use of the cyclohexane dimethanol diacrylate esters as a crosslinking reagent with the specific monomers claimed in the '876 patent. It also fails to suggest that the dimethanol diacrylate esters would provide a polymeric layer satisfying the explicitly disclosed criteria for layers applied via a plasma (i.e., glass transition temperature greater than or equal to that of HSPET), alone or in combination with another monomer. (Ex. 2001 ¶ 74.)

6. Francesch

Francesch is an article entitled “Fabrication of Bioactive Surfaces by Plasma Polymerization Techniques Using a Novel Acrylate-Derived Monomer.” As the title suggests, Francesch relates to the fabrication of bioactive surfaces using a new monomer, pentafluorophenyl methacrylate (PFM), synthesized by the authors. (Ex. 1009 at 605.) The resulting coatings “leave the labile pentafluorophenyl group on the surface, enabling a rapid reaction with an amino-terminated biotin ligand and allowing layer-by-layer self-assembly of biotin-streptavidin.” (*Id.*) Francesch describes that the novel PFM monomer can be deposited alone or can be copolymerized with 1,7-octadiene or 1,4-butanediol divinyl ether (BDVE) as crosslinkers to form the bioactive surface. (*Id.* at 606.)

Such bioactive surfaces have application in tissue engineering and bear no relation to protective coatings for electronic devices. (*Id.* at 605, 610–11; Ex. 2001 ¶ 76.) Francesch also does not disclose or suggest the use of BDVE with the specific monomers claimed in the '876 patent. (Ex. 2001 ¶ 76.) Contrary to Petitioner's assertion, one of skill in the art would not look to Francesch to improve a protective coating or plasma coating process for an electronic device. (*Id.* ¶ 77.)

7. Tropsch

Tropsch is entitled "Preparation of Polymers Comprising Peroxycarboxyl Groups." (Ex. 1011 at 1:4–7.) The objective of Tropsch's work is to "provide a process for preparing polymers comprising peroxycarboxyl groups by reacting polymers comprising monoolefinically unsaturated dicarboxylic anhydride basic building blocks with hydrogen peroxide . . ." (*Id.* at 1:26–33.) The disclosed preparation process is a wet method. (*Id.* at 5:6–22.) Tropsch discloses that the polymers prepared using the disclosed process can be used in a wide range of applications, including as bleaches, disinfectants, and cleaners, and as an ingredient in a variety of products such as acne remedies, tooth bleaches, and cuticle softeners. (*Id.* at 5:60–6:21.) Tropsch describes that the polymers can be crosslinked using "any suitable crosslinker[]" and mentions numerous classes and dozens of specific examples, including 1,6-hexanediol divinyl ether. (*Id.* at 3:47–54, 4:34–39.)

Tropsch is not relevant to plasma polymerization or plasma-derived protective coatings. (Ex. 2001 ¶ 79.) Tropsch does not disclose or suggest using 1,6-hexanediol divinyl ether in a plasma polymerization process, that this compound is suitable as a crosslinking reagent for forming plasma-derived protective polymer coatings, or that it should be used with the specific monomer structures specified in claim 1 of the '876 patent.

C. Level of Ordinary Skill

Petitioner contends that a person of ordinary skill in the art ("POSA") at the time of the priority date of the '876 patent would have had at least a bachelor's degree in a field such as chemistry, physics, or chemical engineering, as well as at least two years of experience with plasma-polymerization techniques. (Pet. at 18.) P2i does not dispute this characterization of the level of ordinary skill in the art for the purpose of this Preliminary Response, with the understanding that "experience with plasma-polymerization techniques" includes plasma-enhanced chemical vapor deposition (PECVD) techniques. (Ex. 2001 ¶ 20; Ex. 1002 ¶ 12, equating PECVD with plasma polymerization.)

Notably, such person of ordinary skill, having only a bachelor's degree and two years of experience in the relevant field, would not have the level of knowledge and insights that Dr. Gleason assumes when attempting to fill the gaps between the disparate teachings of the asserted prior art references. (Ex. 2001 ¶¶ 35, 36.)

III. CLAIM CONSTRUCTION

Petitioner contends that the term “halogen” in claim 1 includes at least fluorine, chlorine, and bromine. P2i does not dispute this construction.

The Petition assumes that the preamble of claim 1 – “an electronic or electrical device or electronic or electrical component thereof” – is a claim limitation. P2i agrees that the preamble is limiting. A preamble limits the invention if it recites essential structure or steps, or if it is “necessary to give life, meaning, and vitality” to the claim. *Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1305 (Fed. Cir. 1999). Dependence on a preamble phrase for antecedent basis indicates a reliance on both the preamble and claim body to define the claimed invention. *Bell Commc'ns Research, Inc. v. Vitalink Commc'ns Corp.*, 55 F.3d 615, 620 (Fed. Cir. 1995).

The preamble of claim 1 is necessary to give meaning to what the claimed invention is, i.e., an electronic/electrical device or electronic/electrical component. Furthermore, the body of the claim refers to forming a coating “on a surface of said device or component” and relies on the preamble for antecedent basis of that device or component. *See Pacing Technologies, LLC v. Garmin Intern., Inc.*, 778 F.3d 1021, 1024 (Fed. Cir. 2015) (“Because the preamble terms “user” and “repetitive motion pacing system” provide antecedent basis for and are necessary to understand positive limitations in the body of the claims in the ‘843 patent, we hold that the

preamble to claim 25 is limiting.”). Accordingly, the preamble of claim 1 limits the claims to an electronic/electrical device or component.

IV. LEGAL STANDARDS

In an *inter partes* review, the petitioner bears the burden to prove unpatentability of the claims of the patent-at-issue by a preponderance of the evidence. 35 U.S.C. § 316(e); *Aqua Products v. Matal*, 872 F.3d 1290, 1303 (Fed. Cir. 2017) (en banc).

Under 35 U.S.C. § 103, Petitioner must prove that the claimed subject matter would have been obvious to a POSA at the time of the invention. *KSR*, 550 U.S. at 406. A complete analysis requires that the Board determine (1) the scope and content of the prior art; (2) differences between the prior art and the claims; (3) the level of ordinary skill in the art; and (4) relevant objective indicia of nonobviousness (also known as secondary considerations). *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17 (1966). Importantly, the obviousness inquiry must be undertaken without any “hint of hindsight.” *Star Scientific, Inc. v. R.J. Reynolds Tobacco Co.*, 655 F.3d 1364, 1375 (Fed. Cir. 2011).

An invention “composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.” *KSR*, 550 U.S. at 418. Moreover, Petitioner is required to show, but does not, that its disparate references would have suggested to a POSA that they should make the

claimed invention and that they would have a reasonable expectation of success in doing so. *In re NuVasive, Inc.*, 842 F.3d 1376, 1381–82 (Fed. Cir. 2016); *Intri-Plex Techs., Inc. v. Saint-Gobain Performance Plastics Rencol Ltd.*, IPR2014-00309, Paper 83 at 19 (PTAB Mar. 23, 2014).

It is not enough to show that multiple references could be combined. Petitioner must show, but does not, that a POSA would have been motivated to pick out the asserted multiple references and combine them in the way the claimed invention does. *Personal Web Techs., LLC v. Apple, Inc.*, 848 F.3d 987, 993–94 (Fed. Cir. 2017); *Ariosa Diagnostics v. Verinata Health, Inc.*, IPR2013-00276, Paper 64 at 17–18 (PTAB Aug. 15, 2016).

Petitioner must support its obviousness contentions with articulated reasoning and based on rational, factual underpinnings; conclusory statements of obviousness will not suffice. *KSR*, 550 U.S. at 418; *In re NuVasive*, 842 F.3d at 1382–83. Similarly, any expert testimony must explain in detail how specific references could be combined, which combinations of elements in specific references would yield a predictable result, and how any specific combination would operate or read on the asserted claims. *Activevideo Networks, Inc. v. Verizon Commc'ns, Inc.*, 694 F.3d 1312, 1327 (Fed. Cir. 2012); *Ariosa*, IPR2013-00276, Paper 64 at 20.

V. THE PETITION FAILS TO ADEQUATELY EXPLAIN THE SUPPORTING EVIDENCE AND ASSERTS EXCESSIVE REDUNDANT GROUNDS THAT WARRANT DENIAL OF INSTITUTION

Trial should not be instituted because the Petition chronically fails to explain the significance of the evidence and frequently incorporates by reference the Gleason declaration, which suffers the same defects as the Petition. A petition for *inter partes* review must “identif[y], in writing and with particularity, each claim challenged, the grounds on which the challenge to each claim is based, and the evidence that supports the grounds for the challenge to each claim.” 35 U.S.C. § 312(a)(3). According to 37 C.F.R. § 42.104(b)(5), the petition must “identify[] specific portions of the evidence that supports the challenge.” Further, 37 C.F.R. § 42.22(a)(2) states that the petition must include “[a] full statement of the reasons for the relief requested, including a detailed explanation of the significant of the evidence including material facts, and the governing laws, rules, and precedent.” The Petition should be rejected because it fails to satisfy each of these requirements.

The Petition makes numerous conclusory assertions that cite to numerous references, or to the Gleason declaration, without sufficient explanation. As but one example of this objectionable tactic, the Petition states: “A POSA also would have known that DVTMDS was compatible with various polymerization methods, including plasma polymerization. Ex. 1002 ¶ 132; see e.g., Ex. 1006 1:31-34; Ex. 1017 Abstract, 4:1-30; Ex. 1033 at [0040-43].” (Pet. at 37.) Turning to the cited

paragraph of Dr. Gleason's declaration, Dr. Gleason makes the same conclusory statement followed by a string citation to unexplained references: "DVTMDS was known to be compatible with various polymerization techniques, including plasma polymerization. Ex. 1006 at 1:32-62; Ex. 1017 at Abstract, 3:40-4:24; Ex. 1027 at 1:5-11, 8:30-35; Ex. 1033 at [0037-45]; Ex. 1036 at 3-6." (Ex. 1002 ¶ 132.) As another example, the Petition states: "Badyal would have motivated the POSA to improve the Coulson-122 coatings by adding a crosslinking reagent during plasma polymerization because Badyal taught—and a POSA would have known—that crosslinked polymer coatings typically exhibited improved durability, barrier properties, smoothness, and solvent resistance." (Pet. at 34–35, citing "Ex. 1005 1:31-2:1, 4:1-29; Ex. 1006 3:51-65; Ex. 1002 ¶¶ 129-131.")

In making such conclusory assertions without providing any explanation of how the cited evidence supports the assertions, Favored fails to make its arguments accessible and forces the Board and P2i to "play archeologist with the record." *See Cisco Systems, Inc. v. C-Cation Technologies, LLC*, IPR2014-00454, Paper 12 at 10 (PTAB Aug. 29, 2014) (*citing DeSilva v. DiLeonardi*, 181 F.3d 865, 866–67 (7th Cir. 1999)). The Petition's conclusory analysis with unexplained citations fails to identify with particularity the significance of supporting evidence for its challenge as required under 35 U.S.C. § 312(a)(3), 37 C.F.R. § 42.104(b)(5), and 37 C.F.R. § 42.22(a)(2).

The examples above and others show that the Petition is also rife with improper incorporation of arguments and evidence from the Gleason Declaration. (See, e.g., Pet. at 71: “Similarly, crosslinkers in the asserted grounds were also known to produce coatings with those properties. Ex. 1002 ¶¶ 132, 151, 153, 165, 171-172, 184, 197, 209.”) 37 C.F.R. § 42.6(a)(3) prohibits arguments from being incorporated by reference from one document to another in an IPR proceeding. See *Cisco Systems, Inc.*, IPR2014-00454, Paper 12 at 10 (refusing to consider arguments not made in petition but incorporated by reference from expert's declaration). Such unsupported arguments and unexplained evidence amount to improper incorporation by reference and should be disregarded by the Board.

Accordingly, the Board should deny institution. See *Apple, Inc. v. ContentGuard Holdings, Inc.*, IPR2015-00440, Paper 11 at 10 (PTAB July 13, 2015) (denying institution for failing to provide sufficient detailed explanation of the significance of citations as required under 35 U.S.C. § 312(a)(3), 37 C.F.R. § 42.104(b)(5), and 37 C.F.R. § 42.22(a)(2)).

The Petition's problems with particularity and incorporation by reference are exacerbated by (or are the result of) the excessive redundant grounds asserted in the Petition. Because of the requirement to institute trial on all grounds and claims asserted in a petition, “the Board may consider whether a lack of particularity as to one or more of the asserted grounds justifies denial of an entire Petition.” *Adaptics*

Ltd. v. Perfect Company, IPR2018-01596, Paper 20 at 17 (PTAB Mar. 6, 2019).

Here, in addition to lacking sufficient particularity, the Petition includes five redundant grounds, each of which significantly overlaps the others. (Pet. at 4:2–10.)

Petitioner fails to provide any explanation justifying the need to present numerous alternative grounds. *Adaptics*, IPR2018-01596, Paper 20 at 21–22 (denying institution of trial due to voluminous grounds, noting “Petitioner fails to explain why it needs to assert so many grounds and references to show unpatentability” and that “[t]he number of asserted grounds and references is disproportionately large when compared with the number of distinct challenged claims.”). In the interests of efficient administration of the Office and integrity of the patent system, the Board should exercise its discretion under 35 U.S.C. § 314(a) and deny institution. *Adaptics*, IPR2018-01596, Paper 20 at 3 (denying institution of trial due to voluminous and excessive grounds, noting “[e]ven when a petitioner demonstrates a reasonable likelihood as to at least one claim, however, institution of an IPR remains discretionary.”).

VI. THE PETITION FAILS TO ESTABLISH A REASONABLE LIKELIHOOD THAT AT LEAST ONE CLAIM IS OBVIOUS

The asserted grounds also fail on the merits. In order to show a reasonable likelihood that claim 1 of the ’876 patent is obvious in view of the prior art, Petitioner must show that one skilled in the art 1) would have been motivated to use the proposed combination of prior art references to 2) predictably achieve the claimed

invention. *Activevideo*, 694 F.3d at 1312. As discussed below, Petitioner fails to make such a showing.

The Petition does not cite any prior art demonstrating that it was known to form a protective cross-linked polymeric coating on an electronic device or component by exposing the device to a plasma comprising one of the recited crosslinker reagents in combination with one of the recited monomer compounds. Neither Coulson nor Badyal disclose electronic devices coated by such a process. Petitioner does not contend otherwise.

Petitioner attempts to plug this fatal gap in its primary references by resorting to a hodgepodge of secondary references, none of which is directed to a similar plasma deposition process or is even pertinent to the particular problems with plasma deposition coatings for electronics solved by the invention of the '876 patent. According to Petitioner, those non-analogous secondary references would have motivated a POSA to select a crosslinker from the recited species to combine with PFAC8 or PFMAC8 in a plasma because Badyal supposedly teaches that any crosslinker known in the polymer art should be used. (Ex. 1002 ¶ 53.) However, a POSA would have read and considered Badyal's entire disclosure, not just the one sentence that Petitioner presents out of context to distort its meaning, and would have concluded from the reference as a whole that Badyal focuses on a particular species of crosslinkers that is not the species recited in claim 1.

Petitioner starts with Coulson-122, which describes an electrical device having a plasma polymerized coating. (Pet. at 26:8–11; Ex. 1004 at 3:20–26.) Although Coulson-122 discloses that the monomer PFAC8 or PFMAC8 may be used (Ex. 1004 at 12:14–22), which are among the monomers recited in claim 1, Coulson-122 does not disclose or suggest using a crosslinker or that a crosslinker would provide any benefit. Coulson-122, of course, provides no data or other information pertinent to the subsequent unexpected discovery in the '876 patent that tack and smudge-free, water repellant coatings of suitable electrical resistance for electronic devices could be produced by supplementing PFAC8 or PFMAC8 plasmas with one of the specifically recited crosslinker reagents.

For the use of a crosslinker in a PFAC8 or PFMAC8 monomer plasma, Petitioner looks to Badyal, which focuses on plasma polymerized coatings for fabrics. (Pet. at 27:5–15; Ex. 1005 at 9:1–19.) Badyal also alludes generally to coating surfaces other than fabrics but lacks any suggestion or showing that his process would form cross-linked protective polymeric coatings suitable for electronic devices. Moreover, Badyal fails to disclose any of the crosslinkers claimed in the '876 patent. In particular, the crosslinker of Badyal lacks the linker moiety L required in the claimed crosslinking reagent. (Ex. 2001 ¶ 62.)

With Coulson-122 and Badyal each failing to disclose or suggest the claimed subject matter, Petitioner looks to the five additional secondary references—Cohen,

Holliday, Padiyath, Francesch, and Tropsch—for the crosslinker reagents recited in claim 1 of the '876 patent. (Pet. at 25:15–21, 42:10–44:6, 52:5–54:3, 57:6–59:1, 64:1–65:7.) Petitioner picks and chooses various crosslinkers buried in these secondary references to piece together the claimed combination of monomer compound and crosslinking reagent. Three of the secondary references are not even related to plasma polymerization. None of them disclose use of the claimed monomer with the claimed crosslinking reagent. (Ex. 2001 ¶¶ 66, 70, 74, 76, 79.)

Petitioner thus impermissibly uses claim 1 of the '876 patent as a roadmap to incorporate a general class crosslinkers useful for Badyal's fabric coating process into the electronics coating process of Coulson-122, and then to select the claimed crosslinking reagents from the disparate secondary references to arrive at the claimed crosslinking reagent.

These and other flaws in Petitioner's evidence and arguments are addressed further below.

A. All Grounds: A POSA Would Not Have Been Motivated to Incorporate the Crosslinkers of Badyal Into the Coating of Coulson-122

Coulson-122 does not disclose a crosslinker; for this Petitioner relies on Badyal. Petitioner asserts that a POSA would have been motivated to combine the teachings of Coulson-122 and Badyal on a path towards the claimed invention. (Pet.

at 34:8–36:10.) However, Petitioner fails to provide a sufficient motivation for a POSA to incorporate a crosslinker into the coating of Coulson-122.

Coulson-122 is directed primarily to coating electronic devices, such as microphones, to protect the devices from liquid damage. (Ex. 1004 at 1:3–7, 6:1–17.) Badyal focuses on the different application of coating fabrics (Ex. 1005 at Abstract, 1:14–15, 9:30–32, 11:22–24). Badyal never refers to electronic devices or electronic components. Thus, a POSA interested in improving Coulson-122's method of coating electronic devices would not find useful guidance in Badyal. (Ex. 2001 ¶ 81.)

Petitioner emphasizes that Badyal mentions that his process could be used to coat “any solid substrate, such as fabric, metal, glass, ceramics, paper or polymer.” (Pet. at 35; Ex. 1005 at 9:28–34.) It is only with the benefit of hindsight that Petitioner equates this generic comment, or the equally vague mention of “biomedical devices” (Ex. 1005 at 11:22–24) to solid surfaces of electronics. A POSA reviewing Badyal at the time of the invention of the '876 patent, but without the benefit of the '876 patent disclosure, would not have discerned that Badyal was referring to electronics or that the inclusion of a crosslinker in a PFAC8/PFMAC8 plasma could improve the characteristics of protective coatings required for particular applications to electronic devices. (Ex. 2001 ¶ 59.)

Coulson-122 focuses on a particular problem that arises for electronic devices that reproduce sound via transducers, such as microphones. (Ex. 1004 at 2:1–3.) Such devices are very susceptible to liquid damage as liquid exposure may impact operability of the transducer and sound quality. (Ex. 1004 at 2:3–12.) Coulson-122 emphasizes that a main benefit of the coatings disclosed therein is their ability to protect a microphone “from liquid contamination without any loss of sound quality.” (*Id.* at 6:2–7.)

By contrast, Badyal is concerned with producing oil and water repellent coatings for protecting a fabric. (Ex. 1005 at 1:14–19, 1:25–2:8, 2:31–3:2, 4:26–29, 9:28–34, 10:1–6, 11:22–24.) The particular fabrics of interest include those for outdoor, sportswear, leisure wear, and military applications. (*Id.* at 1:14–19.) Badyal's primary objective is to improve the durability of such fabric surfaces without affecting the fabric's air permeability—a coating must be able to form durable bonds with the fabric, for example, to withstand washing. (*Id.* at 1:25–34, 4:26–29.)

A POSA would recognize that a plasma coating optimized for treating fabric may not be suitable for coating an electronic device, especially given the differences between these two disparate applications. (Ex. 2001 ¶¶ 59, 81.) In particular, as Coulson-122 confirms, electronic devices “are very sensitive to damage caused by liquids.” (Ex. 1004 at 1:10–11.) For example, Coulson-122 recognizes that

“[c]ontact with liquids either in the course of normal use or as a result of accidental exposure, can lead to short circuiting between the electronic components, and irreparable damage to circuit boards, electronic chips etc.” (*Id.* at 1:11–15.)

Coulson-122 specifically teaches that the properties of plasma synthesized coatings “can depend upon the nature of the substrate as well as the monomer used and conditions under which it is deposited.” (*Id.* at 3:9–12.) Rather than incorporating a separate crosslinker, Coulson-122 focus on factors such as the ratio of monomer vapour to carrier gas (*id.* 7:25–30), surface pretreatment steps (*id.* at 8:11–18), and applied reactor power (*id.* 9:15–10:15) to achieve the desired coating properties. A POSA would not have been motivated to consult a reference focused on coating fabrics for additional guidance about how to satisfy the rigorous protective requirements for electronic devices. (Ex. 2001 ¶¶ 59, 81.)

Petitioner argues that a POSA would have been motivated to combine Coulson-122 and Badyal to obtain protective coatings with “enhanced durability.” (Pet. at 34:19–35:6.) However, a POSA would have been aware that crosslinked polymers tend to be more stiff and rigid compared to non-crosslinked polymers. (Ex. 2001 ¶ 82.) Such rigidity is not necessarily desirable for electronic devices. (*Id.*) For example, in Coulson-122 a key objective is to protect electronic devices while also not having an “adverse impact on sound quality.” (Ex. 1004 at 2:11–12.) Increased

polymer rigidity caused by using a crosslinker may negatively impact sound quality, discouraging a POSA from incorporating a crosslinker. (Ex. 2001 ¶¶ 81, 82.)

Coulson-122 was published more than 7 years after Badyal. Despite overlapping inventors, Coulson-122 never suggests that Badyal's crosslinkers, or any crosslinker for that matter, would improve the coating characteristics required for electronic devices. A POSA would have been especially skeptical that the crosslinkers disclosed in Badyal could improve the process for coating electronics disclosed in Coulson-122 when Coulson-122 itself does not suggest this. (*Id.* ¶ 84.)

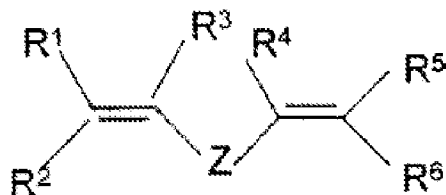
Such a person would have been led away from incorporating a crosslinker in the coating of Coulson-122 for additional reasons. For example, the increased rigidity resulting from adding a crosslinker may be undesirable for movable components, as movement could cause cracking which may compromise the coating. (*Id.* ¶ 83.) Additionally, Coulson-122 shows that a coating for electronics having oil- and water-repellant properties can be achieved without the need for a crosslinker. (Ex. 1004 at 4:29–5:6.) To achieve a more economical process, while carefully controlling the nature and amount of monomer used as taught by Coulson-122, a POSA would have been motivated to prepare a coating using fewer reagents and would not reach for additional, unnecessary reagents, especially considering such an addition could negatively impact sound quality. (Ex. 2001 ¶ 83.) Adding more reagents also increases the complexity of a plasma polymerization process and may

present additional challenges delivering multiple reactants uniformly. (*Id.*) If reactants are not delivered uniformly, the resulting polymer will lack uniformity and be non-conformal. (*Id.*)

Petitioner fails to take into account the differences between the type of coating addressed in Badyal and the type of coating in Coulson-122 and provides no persuasive reason why a POSA would have gone beyond the important process factors taught in Coulson-122 to add a crosslinker of the type disclosed in Badyal.

B. All Grounds: A POSA Would Not Have Been Motivated by Badyal to Include the Bridging Groups Petitioner Lifts From the Secondary References

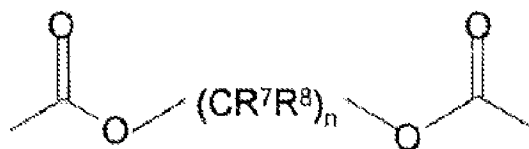
The Petition asserts that, within the generic crosslinker structure disclosed in Badyal's formula (I):



(Ex. 1005 at 4:31–5:5), “Badyal taught that ‘suitable bridging groups Z’ included ‘those known in the polymer art’.” (Pet. at 25:2–8, 31:5–7; Ex. 1005 at 5:18–19.) Dr. Gleason’s declaration and the Petition repeatedly characterize Badyal in that manner while ignoring the surrounding context of the sentence upon which they rely. (See Pet. at 25:4–6, 31:5–7, 34:1–2, 39:1–3; Ex. 1002 ¶¶ 70, 125, 132, 192.) This is improper as a matter of law. In an obviousness analysis, prior art references must be

viewed as a whole and consideration must be given of aspects that diverge and teach away from the claimed invention. *Takeda Chem. Indus., Ltd. v. Alphapharm Pty., Ltd.*, 492 F.3d 1350, 1358 (Fed. Cir. 2007); *W.L. Gore & Associates, Inc. v. Garlock*, 721 F.2d 1540, 1550 (Fed.Cir.1983).

Badyal's disclosure as a whole does not teach that the crosslinker may include any bridging group Z known in the polymer art as Petitioner contends. Badyal makes clear that suitable crosslinking compounds must be suitable for use in plasmas "which will yield cross-linked polymers having oil or water repellent properties." (Ex. 1005 at 4:17–21.) Badyal characterizes the "suitable bridging groups" as being "known in the polymer art" only in the context of disclosing more specifically the identity of those "suitable bridging groups." (*Id.* at 5:18–19.) Badyal first states that the suitable bridging groups include "optionally substituted alkyl groups which may be interposed with oxygen atoms," and preferably "one or more acyloxy or ester groups." (*Id.* at 5:20–26.) Badyal then provides the chemical formula (II) for a preferred species of suitable bridging groups:



where n is an integer of from 1 to 10, suitably from 1 to 3, each R¹ and R² is independently selected from hydrogen, alkyl or haloalkyl.

(*Id.* at 5:26–6:3.) The reference also discloses example crosslinker compounds A and B derived from incorporating such bridging groups in to the crosslinker formula (I). (*Id.* at 6:15–6:20.) None of the preferred bridging groups Z result in a crosslinker reagent among the species of crosslinkers recited in claim 1. (Ex. 2001 ¶ 62.)

Accordingly, rather than teaching that any bridging group Z known in the polymer art generally could be used in the disclosed crosslinking compounds, Badyal discloses a specific species of bridging groups Z while confirming that those “suitable bridging groups Z” are known in the polymer art. Notably, both the Petition and Dr. Gleason’s declaration are silent regarding the portions of Badyal stating that the suitable bridging groups are those structured according to formula (II).

Because a POSA would not read Badyal’s disclosure as so expansive to include crosslinkers of formula (I) having any bridging group Z known in the polymer art, Badyal would not have motivated a POSA to select a bridging group from any of the unrelated secondary references—Cohen, Holliday, Padiyath, Francesch, and Tropsch—instead of a group described by Badyal’s formula (II). (*Id.* ¶¶ 61, 85.)

Even if Badyal could be fairly read as teaching that the crosslinker can include any bridging group Z known in the polymer art generally, such a teaching still would not have motivated a POSA to select the claimed crosslinker reagents from the secondary references. A claim directed to a chemical compound is not rendered

obvious where the prior art “does not teach a finite and limited class including [the claimed compound].” *See Shire LLC v. Amneal Pharmaceuticals, LLC*, 802 F.3d 1301, 1307–1308 (Fed. Cir. 2015) (claims were not obvious where prior art reference broadly taught a genus including thousands of possible compounds and thirty specific examples, none of which were the claimed compound). Like the reference in *Shire*, if Badyal describes the bridging group Z in a manner that is so expansive, then it fails to describe a meaningful preference that would have led a POSA to arrive at the particular structures for the linker moieties L in claim 1 of the ’876 patent. Teaching such a broad class of bridging groups—not limited to a finite class—would not have provided a motivation to select bridging groups that satisfy the specific structures recited in claim 1 of the ’876 patent.

Petitioner may not use the ’876 patent specification as a roadmap to pick and choose favorable teachings from prior art references. *In re Wesslau*, 353 F.2d 238, 241 (CCPA 1965) (holding hindsight reconstruction impermissible and requiring that prior art references be considered in their entirety to fully appreciate what a reference suggests to a POSA). As the *Wesslau* court explained “[i]t is impermissible within the framework of section 103 to pick and choose from any one reference only as much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art.” *Id.* That is exactly what Petitioner has done in selecting

bridging groups from the secondary references, to the exclusion of contrary teachings in Badyal.

C. Grounds 1, 2, 4 and 5 Fail For the Threshold Reason That They Rely on Non-Analogous Prior Art

Four of the asserted secondary references have nothing to do with plasma polymerized protective coatings or the problem the inventors of the '876 patent were trying to solve: creating improved plasma polymerized protective coatings for electronic devices. Accordingly, these references cannot be applied in an obviousness combination. Grounds 1, 2, 4 and 5 fail because they rely on non-analogous art.

In order for a prior art reference to be proper for use in an obviousness rejection under 35 U.S.C. § 103, the reference must be analogous art to the claimed invention. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004); *MPEP* § 2141.01(A). A reference is analogous art to the claimed invention only if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). *Id.* In order for a reference to be "reasonably pertinent" to the problem, it must "logically[] have commended itself to an inventor's attention in considering his problem." *In re Icon Health and Fitness, Inc.*, 496 F.3d 1374, 1379–80 (Fed. Cir. 2007) (quoting *In re Clay*, 966 F.2d 656, 659 (Fed. Cir. 1992)). The relevant problem

to consider is the problem faced by the inventor, as reflected—either explicitly or implicitly—in the specification. *In re Klein*, 647 F.3d 1343, 1348–51 (Fed. Cir. 2011).

1. Cohen is Non-analogous Art

The '876 patent's field of endeavor relates to plasma polymerized protective coatings. The specification and claims of the '876 patent confirm that the field of endeavor is plasma polymerized protective coatings.

The structure of the invention recited in claim 1 clearly requires an electronic device having a protective coating, obtained by exposing the device to a plasma. (Ex. 1001 at 18:26–36.) The Field of Invention in the '876 patent states “the present invention relates to protective coatings for electronic or electrical devices and components thereof, and methods for forming such coatings.” (*Id.* at 1:5–13.) Each example in the '876 patent similarly involves plasma polymerized protective coatings. (*Id.* at 15:40–16:54, 16:58–17:19.) The descriptions of the inventive subject matter in the '876 patent clearly illustrate that the inventors' field of endeavor relates to plasma polymerized protective coatings.

The '876 patent explicitly describes the problems that the inventors were addressing: obtaining protective coatings that did not smear, were tack free, but also had sufficient protective qualities suitable for electronic devices, including hydrophobicity and/or electrical resistance. (*Id.* at 1:15–2:6.) The inventors of the

'876 patent were confronted with problems specific to plasma polymerization, and in particular in relation to known plasma derived coatings formed by PFAC8 and PFAC6. In particular, the problems described in the Background relate to the impact of power input to the *plasma* on the nature of the polymerized coating—a problem specific to plasma polymerization. (*Id.* at 1:20–21.) In plasma polymerized coatings, power of the plasma affects fragmentation the monomer, impacting properties of the coating such as water contact angle and resistance to smudging. (*Id.* at 1:20–33, 57–67.) At the end of the Background section, the '876 patent explicitly provides that “it is an aim to solve one or more of the above-mentioned problems with the prior art coatings.” (*Id.* at 2:5–7.) The inventors of the '876 patent therefore expressly described the particular problems they faced, all which involved plasma polymerized protective coatings for electronic devices.

Cohen is far afield from the field of endeavor as the '876 patent. Cohen provides no information relevant to plasma polymerization or protective coatings obtained thereby. Cohen instead focuses on conventional polymerization reactions involving a particular disiloxane monomer (DVTMDS). (Ex. 1006. at 1:31–63.) Cohen aims to provide dielectric materials and filling compounds for use in devices such as capacitors and cable joints, not nanoscale protective coatings of the type relevant to the '876 patent. (*Id.* at 5:1–21.)

Cohen is also not reasonably pertinent to the problem faced by the inventors of the '876 patent—creating improved plasma polymerized protective coatings for electronic devices. Cohen does not explicitly describe any problem it is attempting to solve, but rather describes a new compound divinyltetramethydisiloxane, how it may be synthesized, and how it may be copolymerized with other compounds using conventional polymerization methods. (*Id.* Examples 1–5.) None of this has any relevance whatsoever to plasma polymerization or protective coatings for electronic devices formed by plasma polymerization. Thus, a POSA would not look to Cohen when faced with problems specific to improving protective coatings formed via plasma polymerization processes. (Ex. 2001 ¶¶ 65–67.)

Petitioner's assertion that a POSA would have been drawn to Cohen for guidance on which crosslinkers to use in a plasma deposition process of the type disclosed in Badyal or Coulson-122 is imbued with impermissible hindsight. The Federal Circuit has made clear, however, that the pertinence of the reference to the inventor's problem "must be recognizable with the foresight of a person of ordinary skill, not with hindsight of the inventor's successful achievement." *Airbus S.A.S. v. Firepass Corp.*, 941 F.3d 1374, 1382 (Fed. Cir. 2019) (citing *Sci. Plastic Prods, Inc. v. Biotage AB*, 766 F.3d 1355, 1359 (Fed. Cir. 2014) (citations omitted)).

2. Holliday is Non-analogous Art

Holliday is also completely unrelated to plasma polymerized coatings for electronic devices. As discussed above, Holliday provides curable compositions which are applied to the surface of an object by dipping the object into the composition. (Ex. 1007 at 2:60–64.) After coating, the composition is subsequently cured to form a crosslinked layer. (*Id.* at 2:64–70.) This is an entirely different field than the plasma polymerization process relevant to the invention of the '876 patent. Holliday also is not pertinent to addressing challenges associated with controlling the tackiness, smear resistance, water resistance and electrical barrier properties of ultra-thin film plasma polymerized coatings for electronics. (Ex. 2001 ¶¶ 70–71.)

3. Francesch is Non-analogous Art

Francesch is also unrelated to plasma polymerized protective coatings for electronic devices. It relates to an entirely different field—plasma derived coatings for *bioactive surfaces*. (Ex. 1009 at 605–606, 610.) Francesch also would not have commended itself to the attention of a POSA considering the problem of creating improved hydrophobic and barrier coatings for electronic devices. Francesch addresses completely unrelated problems:

Targeting materials to specific cells, designing materials that can sense biochemical signals and developing materials with improved biocompatibility remain challenges in biomaterials development. Significant effort remains in increasing the cell recognition and

attractiveness of biomaterial surfaces. Modified materials stimulate cell adhesion, growth and proliferation, while maintaining the mechanical attributes of the bulk material.

(*Id.* at 605.)

The problems addressed in Francesch—targeting cells, sensing biochemical signals, biocompatibility—are narrowly tailored to surface characteristics of substrates for targeting cell adhesion rather than to characteristics for providing water resistant and barrier coatings for protecting electronic devices. For example, to provide a surface that binds bioactive molecules, Francesch focuses on parameters like the extent to which a surface effectively binds biotin. (*Id.* at 609–610.) Such properties are irrelevant to the problem addressed by the inventors of the '876 patent. A POSA would have no interest in a plasma process designed to provide bioactive surfaces when attempting to solve problems unique to providing improved hydrophobic and barrier coatings for electronic devices. (Ex. 2001 ¶¶ 76–77.)

4. Tropsch is Non-analogous Art

Tropsch is also not from the same field of endeavor as the '876 patent. Tropsch relates to “processes for preparing polymer comprising peroxydicarboxyl groups.” (Ex. 1011 at 1:4–7.) Tropsch fails to describe plasma polymerization, coatings for electronic devices, coatings generally, or any properties suggesting its polymers would form protective coatings for electronic devices.

A POSA would certainly not consider Tropsch relevant to plasma polymerized coatings for electronic devices. (Ex. 2001 ¶ 79.) The laundry list of potential applications for the disclosed polymers confirms this:

The polymers comprising peroxy-carboxyl groups prepared according to the invention can be used in a wide range of applications, for example as bleaches, disinfectants, cleaners or for epoxidation. Applications both in the cosmetic and in the pharmaceutical Sectors are possible. Examples of Such applications are in the Sectors: acne remedies, tooth bleaches, or lightening of the teeth, nonaqueous toothpastes and tooth powders, cleaning of dentures and orthodontic appliances, foaming mouthwash tablets, hair removers (oxidizing depilatories), hair bleaches, bleaching of the skin, coupling agents in hair dyeing and production of permanent waves (alkali cold wave), Softening of cuticle, for example in foot care, incorporation in deep bed filter Systems, filled tamponades for Simultaneous absorption and disinfection, disinfecting wipes, disinfectants for medical instruments, Surface disinfection, water disinfection, vaginal Suppositories, non-aqueous ointments, for example polyethylene-based ointments, antibacterial lipsticks, wound dressings, wound powders, contact lens cleaning, cold wash tablets.

(Ex. 1011 at 5:61–6:13.)

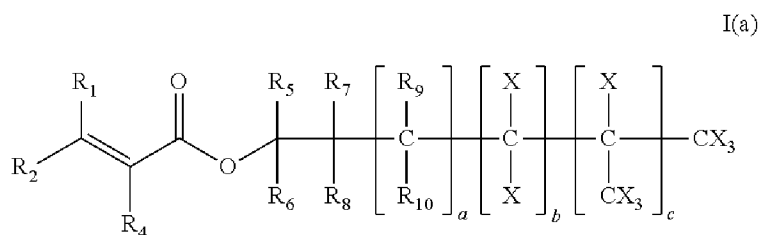
The Petition entirely fails to explain how Tropsch has any relevance to plasma protective coating applications pertaining to electronic devices. Petitioner has not met its burden of demonstrating that a POSA would have considered Tropsch

relevant to the problems that the inventors of the '876 patent faced—providing improved plasma polymerized coatings for electronic devices.

D. All Grounds Fail Because a POSA Would Not Have Been Motivated to Combine Coulson-122 and Badyal With the Asserted Secondary References

Even if any of the asserted secondary references are considered to be analogous art, a POSA would not have been motivated to combine any of them with Coulson-122 and Badyal. Petitioner acknowledges that the combination of Coulson-122 and Badyal alone fails to disclose a plasma deposition process utilizing a crosslinking reagent within the species recited in claim 1. (Pet. at 25:2–4.) Beyond failing to provide any persuasive rationale as to why a POSA would have been motivated to incorporate a crosslinker into the composition of Coulson-122, Petitioner has not shown that a POSA would have been motivated to select one of the specific crosslinker compounds disclosed in any of the asserted secondary references. Each of the asserted grounds should be rejected for this additional reason.

None of the secondary references describe the use of the claimed crosslinking reagents with any of the monomer compounds recited in claim 1 of the '876 patent, which are limited to compounds of formula I(a):



wherein each of R₁, R₂, R₄ and R₅ to R₁₀ is independently selected from hydrogen or an optionally substituted C₁-C₆ branched or straight chain alkyl group; each X is independently hydrogen or halogen; a is from 0-10; b is from 3 to 7; and c is 0 or 1 . . .

(Ex. 1001 at 18:40–53.) Petitioner and Dr. Gleason are keen to emphasize that the PFAC8 and PFMAC8 monomers disclosed in Coulson-122 and Badyal meet this general formula. (Pet. at 15.) However, they have no answer to the fundamental question of why a POSA seeking to improve the characteristics of plasma coatings formed from those monomers would find motivation in references that are not directed to plasma process utilizing those specific monomers or any other monomers recited in claim 1.

In this regard, Dr. Gleason merely characterizes the crosslinkers disclosed in the secondary references as being compatible or usable with acrylate monomers. For example, Dr. Gleason asserts the following:

In addition, a POSA would have known DVTMDS was compatible for co-polymerization with acrylate monomers . . . (Ex. 1002 ¶ 135 (discussing the combination of Coulson-122, Badyal, and Cohen).)

Likewise, a POSA would have known that PFAC8 and PFMAC8 are acrylate-based monomers, and Holliday taught that DCHD and BDVE could be used to make polymer coatings in conjunction with acrylates or methacrylates. (*Id.* ¶ 153) (discussing the combination of Coulson-122, Badyal, and Holliday).)

A POSA also would reasonably have expected that the diacrylate structure of CDMDA would successfully copolymerize with other compounds in the family of acrylate and methacrylate monomers, which includes PFAC8 and PFMAC8 to create protective coatings. (*Id.* ¶ 173) (discussing the combination of Coulson-122, Badyal, and Padiyath).)

Because Francesch described using BDVE as a crosslinker to create plasma polymer coatings by co-polymerizing with a fluorinated methacrylate (PFM), a POSA would have understood that BDVE was suitable for copolymerizing with such monomers belonging to the family of acrylate and methacrylate by plasma polymerization. (*Id.* ¶ 183) (discussing the combination of Coulson-122, Badyal, and Francesch).)

In addition, Tropsch taught that its crosslinkers, which included HDVE as preferred, could be polymerized with acrylates (Ex. 1011 at 3:1-10, 4:34-38), which would have supported a reasonable expectation that HDVE could successfully crosslink other acrylate and methacrylate monomers like PFAC8 and PFMAC8. (*Id.* ¶ 199) (discussing the combination of Coulson-122, Badyal, and Tropsch).)

However, the mere fact that crosslinkers in the secondary references perhaps *could* have been combined with the monomers of Coulson-122 and Badyal is insufficient to show that a POSA *would* have been motivated to make the combination. *See e.g., InTouch Technologies, Inc. v. VGO Communications, Inc.*, 751 F.3d 1327, 1353–54

(Fed. Cir. 2014) (evidence that references could have been combined insufficient to prove obviousness absent evidence demonstrating why one of skill in the art would have been motivated to combine the references); *see also Personal Web Techs.*, 848 F.3d at 993–94.

The Petition lacks any analysis directed to the relevant question of why a POSA would supposedly have been motivated to supplement the PFAC8 or PFMAC8 monomer plasmas disclosed in Badyal and Coulson-122 by addition of one of the crosslinker reagents disclosed in the secondary references. Unable to provide a rational underpinning to support such a theory, Petitioner and Dr. Gleason resort to characterizing Badyal as teaching that “crosslinkers for its plasma-based techniques could be any known in the entire ‘polymer art,’ without limiting consideration to reagents specific for plasma or any other type of polymerization.” (Ex. 1002 ¶ 53.) As discussed above, Badyal’s disclosure is far more specific, and, by mentioning that the preferred bridging groups of the suitable crosslinkers are known in the art, Badyal does not suggest that any crosslinker known in the art could be used. In reading Badyal, a POSA would not look to any crosslinker in the polymer art, but would select instead crosslinkers that conform to the disclosed formula (I) with a bridging group according to formula (II). (Ex. 2001 ¶ 85.) None of the secondary references disclose such a crosslinker. (*Id.*)

Cohen, Holliday, and Tropsch each fail to show that their crosslinkers would yield crosslinked polymers having oil or water repellant properties when used in plasmas. (*Id.* ¶¶ 86, 87, 90, 91.) Those references do not even relate to plasma polymerization. (*Id.* ¶ 91.)

The secondary references that actually do mention plasma processes—Padiyath and Francesch—would still not have provided a motivation to arrive at the specific combination of monomer compounds and crosslinking reagents claimed in the '876 patent. The manner in which crosslinking occurs in Padiyath is different than the manner in which crosslinking occurs in Badyal. Badyal describes exposing a surface “to a plasma comprising one or more organic monomeric compounds, at least one of which comprises two double bonds, so as to form a layer of cross-linked polymer on said surface.” (Ex. 1005 at 4:4–9.) By contrast, Padiyath describes a two-step process in which (1) a polymer layer is formed and (2) the formed layer is then crosslinked. (Ex. 1008 at ¶ 61.) (describing that “[m]ost preferably, the polymer layers are formed by flash evaporation and vapor depositing *followed by* crosslinking in situ . . .”) In fact, this process described in Padiyath leads away from applying the crosslinker in the plasma by teaching a preference for crosslinking in-situ after polymer layers have already been formed. (Ex. 2001 ¶ 89.)

Francesch does not relate to providing protective coatings for electronic devices. A POSA interested in providing improved plasma deposition hydrophobic

or barrier coatings for an electronic device would not have been motivated by Francesch's disclosure regarding bioactive surfaces that will bind certain biological molecules. (Ex. 1009 at 605–606, 610; Ex. 2001 ¶ 77.)

The Petition never explains why a POSA reviewing Badyal would have been motivated to ignore Badyal's recommendation to use a crosslinker of the formula (I) with a bridging group of formula (II), and to select instead a crosslinker disclosed only in a secondary reference unrelated to plasma-derived cross-linked protective coatings. There is no evidence demonstrating that a POSA would have done so.

E. All Grounds Fail Because a POSA Would Not Have Had a Reasonable Expectation of Success Combining the Asserted References

Each of the asserted grounds fails for the additional reason that a POSA would not have had a reasonable expectation of success in combining the particular crosslinkers that Petitioner lifts from the secondary references with the monomers of Coulson-122 and Badyal. In particular, there would have been no reasonable expectation that these crosslinkers and monomers would yield an improved protective coating when applied to an electronic device via a plasma polymerization process.

Cohen, Holliday, and Tropsch each fail to teach use of the claimed crosslinking reagent to produce a protective coating for an electronic device via a plasma polymerization process. Coulson-122 and Badyal discuss the effect of

various process conditions on plasma derived protective coatings, but do not address the potential effects of using a crosslinker of any of those secondary references. A POSA would know that combining a crosslinking reagent to another monomer in a conventional polymerization process will lead to a different result than combining the same compounds in a plasma polymerization process. (Ex. 2001 ¶ 41, 43–44.) Accordingly, a POSA would not have reasonably expected to succeed in combining the crosslinkers lifted from these references with the monomers described in Coulson-122 and Badyal to produce a suitable protective coating via a plasma polymerization process. (*Id.* ¶¶ 37, 91–93.)

Dr. Gleason asserts that “POSAs [] understood and expected that the same types of crosslinking reagents used for conventional polymerization would also work in plasma polymerization reactions.” (Ex. 1002 at ¶ 53.) Dr. Gleason does not elaborate on what it means for a crosslinking reagent to “work” in such a plasma. She fails to address whether this would result in a coating having the properties desired for an electronic device when combined with monomers of Coulson-122 and Badyal. (Ex. 2001 ¶¶ 42, 43.)

Petitioner's assertion that crosslinkers used in conventional polymerization processes would have been reasonably expected to be effective in improving plasma polymerization processes for coating electronic devices is disproven by recognized authorities such as Yasuda, who counsels that one must “appreciate the uniqueness

of plasma polymerization” when developing an improved plasma polymerized protective coating. (Ex. 2002 at 2–3, 4–5, 166–7, 171.) In fact, as described by Yasuda, it was known that:

To take full advantage of the new kinds of materials recognized as plasma polymers and of the process by which they are made, *it is important to recognize that we are not dealing with conventional polymers and polymerization in the strict sense*, although these terms are used. Therefore, considerable effort is spent comparing plasma polymerization with conventional polymerization. (*Id.* at 3)(emphasis added.)

...

Chemical reactions that occur under plasma conditions are generally very complex (2-4) and consequently are nonspecific in nature. Such reactions are of merit when special excited states of molecules are required as intermediate states and cannot be achieved, or can be achieved only with great difficulty, by conventional chemical reactions. Thus, *plasma polymerization should be recognized as a special means of preparing unique polymers that cannot be made by other methods rather than as a special way of polymerizing monomers*. (*Id.* at 4–5)(emphasis added.)

Dr. Gleason acknowledges that “resulting structural complexity distinguishes plasma polymerization from molecular polymerization techniques in which monomer molecules combine through chemical reactions to form relatively uniform chains or networks of repeating monomer units.” (Ex. 1002 ¶ 36.) A POSA,

recognizing that the resulting coatings will be different, would not assume that a crosslinking reagent used in a non-plasma polymerization process would be effective to obtain an improved plasma-derived protective coating. (Ex. 2001 ¶¶ 42, 43.)

Even if the crosslinkers used in conventional polymerizations, such as those described in Cohen, Holliday, and Tropsch, would “work” in the claimed plasma process as Dr. Gleason assumes (Ex. 1002 ¶ 53), a POSA could not have predicted the characteristics of the resulting coating. (Ex. 2001 ¶¶ 43, 44.) The unpredictability of plasma deposition process and uncertainty regarding the structure of polymers produced by plasma polymerization processes was well-known. As Yasuda explains:

In other words, in conventional polymerizations, molecules of monomers are linked together with a minimum alteration of chemical structure of the monomer and the structure of a polymer can be well predicted from the structure of the monomer. In contrast, the structure of a polymer formed by plasma polymerization cannot be predicted in this way.

(Ex. 2002 at 166.) Given the lack of predictability in structures formed via plasma polymerization, a POSA would not reasonably have expected to predict the structure or properties of plasma polymerized coatings based on the use a particular crosslinker in a conventional polymerization process. (Ex. 2001 ¶ 41.)

Petitioner has also not shown that a POSA would have combined the crosslinker of Padiyath with the monomers of Coulson-122 and Badyal with a reasonable expectation of success in producing a protective film suitable for an electronic device. Padiyath discloses a multilayer film including a crosslinked polymer layer. (Ex. 1008 ¶ 52.) Padiyath however does not describe the polymer layer as a barrier layer and, rather, refers to the layer as one layer in the multilayer stack of the barrier assembly. (*Id.* ¶ 51.) In fact, Padiyath teaches away from the invention of the '876 patent by stating that “multiple inorganic layers separated by polymer coatings are needed to achieve superior barrier performance.” (*Id.* ¶ 3.) In reading Padiyath, a POSA would not have expected successful barrier properties from a single crosslinked polymer layer alone. (Ex. 2001 ¶ 88.) Further, Padiyath fails to teach use of the claimed monomer compound and crosslinking reagent together in its polymer layer. Petitioner has not shown that the crosslinker of Padiyath was known to be usable, with a reasonable expectation of success, to create a protective coating for an electronic device, let alone that it could be used with the claimed monomer do to so. (*Id.* ¶ 89.)

Petitioner also has not shown that a POSA would have been led to combine Francesch with Coulson-122 and Badyal with a reasonable expectation of success in producing a protective film for an electronic device. Francesch discloses the fabrication of bioactive surfaces using plasma polymerization using a crosslinker.

(Ex. 1009 at 605.) Francesch does not describe that the crosslinker could be used to obtain a protective coating for an electronic device. Rather Francesch focuses on properties such as the surfaces' ability to bind biological molecules. (*Id.* at 605, 610.) It does not discuss properties, such as water contact angle or resistance, which the '876 patent considers relevant to producing an effective protective coating for an electronic device. (Ex. 1001 at 3:55–4:35.) Francesch also fails to show use of the crosslinker with the claimed monomer compounds or that it could be used to obtain a suitable protective coating for an electronic device using those compounds. (Ex. 2001 ¶ 93.)

Thus, Petitioner has failed to show that a POSA would have had a reasonable expectation that adding a crosslinker selected from any of the secondary references to a PFAC8 or PFMAC8 plasma of Coulson-122 and Badyal would produce a plasma polymerized protective coating suitable for an electronic device.

VII. CONCLUSION

For the reasons described above, and because Petitioner has not shown a reasonable likelihood that any of the claims are unpatentable, the Board should deny institution.

Respectfully submitted,
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Dated: October 30, 2020

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CERTIFICATE OF WORD COUNT

The undersigned hereby confirms that the foregoing Preliminary Response complies with the type-volume limitation of 37 C.F.R. § 42.24(a). Excluding the items listed in 37 C.F.R. § 42.24(a) as not included in the word count, this Preliminary Response contains less than 14,000 words, calculated by the word-processing system used to prepare it.

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CERTIFICATE OF SERVICE

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FAVORED TECH CORPORATION,

Petitioner

v.

P2I LTD.,

Patent Owner

Case No. IPR2020-01198

Patent No. 10,421,876

**PATENT OWNER'S SUR-REPLY TO PETITIONER'S REPLY TO
PRELIMINARY RESPONSE**

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Petitioner's Reply confirms that the Petition is deficient for not having addressed whether any of Cohen, Holliday, Francesch and Tropsch is analogous art. *In re Bigio*, 381 F. 3d 1320, 1325 (Fed. Cir. 2004) ("References . . . qualify as prior art for an obviousness determination only when analogous to the claimed invention."). The Reply still fails to meet Petitioner's threshold burden of proof in this regard, and fails to show that its 5 grounds are not redundant. Accordingly, the Board should deny institution of trial.

I. FOUR OF FIVE GROUNDS RELY ON NON-ANALOGOUS ART

Donner Technology, LLC v. Pro Stage Gear, LLC, No. 2020-1104 (Fed. Cir. Nov. 9, 2020), fails to justify Petitioner's Reply, as it did not change the law regarding analogous art and does not support that the four asserted secondary references here are within the field of endeavor of the '876 patent, or are reasonably pertinent to the problem with which the inventors were involved. The Reply does not address the facts of *Donner* or the Court's actual holding that "[b]ecause the Board failed to identify and compare the problems to which the '023 patent and Mullen [prior art reference] relate, the Board failed to apply the proper standard." *Donner*, slip op. at *10, *12. P2i plainly identified the problems that the '876 patent addresses and showed that each of the secondary references addresses different problems and solutions which are not reasonably pertinent. Petitioner simply ignored these issues altogether. *cf. Donner*, slip op. at *8 (observing that the Petitioner

submitted detailed expert testimony and argument in its petition relevant to the inquiry.) Furthermore, the concern mentioned in *Donner* of defining the problem so as to effectively exclude references outside the field is not implicated here. The problems addressed by the '876 patent do not necessarily preclude all references outside the field from being pertinent. They do preclude the 4 asserted secondary references, which teach nothing relevant to those problems.

The analogous art requirement limits the pertinent art to the fields which a POSA "would reasonably be expected to look for a solution to the problem facing the inventor." *In re Oetiker* 977 F.2d 1443, 1447 (Fed. Cir. 1992). "To determine the applicable field of endeavor, the factfinder must consider 'explanations of the invention's subject matter in the patent application, including the embodiments, function, and structure of the claimed invention.'" *Airbus S.A.S. v. Firepass Corp.*, 941 F.3d 1374, 1380 (Fed. Cir. 2019)(citing *Bigio*, 381 F.3d at 1325.)

Petitioner ignores the thrust of the '876 patent's teachings and invites error by overbroadly characterizing the field of the '876 patent as "polymer coatings." However, simply devising a field broad enough to encompass both the asserted art and the invention is improper. See *In re Clay*, 966 F.2d 656, 659 (Fed. Cir. 1992). First, this characterization is inconsistent with the '876 patent, which reveals through the specification, embodiments, and claims that the field of the endeavor relates solely to *plasma* polymerized *protective* coatings. POPR at 42-43; Ex. 1001 at

18:26–36: reciting “a protective cross-linked polymeric coating . . . obtained by exposing said device or component to a plasma. . . .”; 1:5–13: “the present invention relates to protective coatings for electronic or electrical devices . . .”; 15:40–18:23: each example 1-6 describing plasma polymerized protective coatings.

Petitioner's expert did not assert that the field is as broad as now alleged in the Reply. She acknowledged that “the [‘876] patent discusses crosslinked plasma polymer coatings applied to electronic devices” and notes that the only specialized experience a POSA would have is “at least two years of experience with *plasma* polymerization techniques.” Ex. 1002 ¶¶29, ¶59 (emphasis added.) A POSA would know that “plasma polymerization is a new material preparation process and is not a kind of polymerization”, and that the coatings formed by plasma polymerization are “vastly different from conventional polymers.” Ex. 2001 ¶37; Ex. 2002 ix; Ex. 1002 ¶36: recognizing plasma polymerization as distinct from molecular polymerization. A POSA would not be expected to look to references directed to conventional polymerization processes when looking to solve problems related to creating protective coatings using a plasma polymerization process. Ex. 2001 ¶¶37-40; *See Airbus S.A.S.*, 941 F.3d 1374, 1381 (Fed. Cir. 2019)(finding knowledge of a POSA relevant to scope of the field of endeavor.)

Petitioner even fails to show that each of the asserted references is in the “polymer coatings” field. Cohen instead relates to dielectric materials and filling

compounds for use in devices such as capacitors and cable joints. Ex. 1006 5:1-21. Tropsch relates to preparing polymers comprising peroxycarboxyl groups having applications in bleaches, disinfectants, and cleaners. Ex. 1011 1:26-33; 5:60-6:21. The other references are irrelevant to plasma polymerized protective coatings. Francesch relates solely to plasma-derived coatings for bioactive surfaces. Ex. 1009 605-606, 610. Holliday relates to curable dip coatings for electrical connectors and other conductors. (Ex. 1007 at 1:12–15, 1:23–25, 1:52-2:35, 2:60–64.)

Petitioner fails to conduct any analysis regarding reasonable pertinency, in which “the problems to which both [the asserted reference and the claimed invention] relate *must* be identified and compared.” *Donner*, slip op. at *8 (emphasis added.) Petitioner instead argues the *explicit* description of the problems addressed in the ‘876 patent, which relate to improving the quality and plasma processing range of plasma-derived protective coatings for electronics (Ex. 1001 1:5-13; 1:20-33; 57-67; 2:1-7), “could not possibly be a relevant purpose of the invention” because these problems were allegedly “already solved by known coatings.” This argument fails because the ‘876 patent does not state that the identified problems are solved by known coatings, such as those made with PFAC8. Ex. 1001 1:24-27: stating water contact angle of PFAC8 coatings are “compromised”; *see Donner*, slip op. at *8-9.

Petitioner then argues that ‘876 patent’s purpose relates “to achieving highly crosslinked coatings at low power.” This assertion defeats Petitioner’s own

argument. Achieving highly crosslinked coatings at low power is a problem specific to plasma polymerization, and not polymerization in general. Petitioner does not even allege that any of the 4 asserted references address how to achieve highly crosslinked coatings at low power, and of course, they do not. (POPR 42-48.)

Accordingly, Petitioner fails to establish that the pertinent field is “polymer coatings” or that a POSA would have looked to any of the four non-analogous references to address the problems facing the inventors of the ‘876 patent, which are unique to forming plasma polymerized protective coatings.

II. PETITIONER FAILS TO JUSTIFY ITS REDUNDANT GROUNDS

Petitioner asserts that its 5 redundant grounds are allegedly necessary to “address all claimed crosslinkers.” But this explanation still fails to address why 5 grounds are necessary when each of the 15 claims are challenged with only grounds 1 and 2.

Ground	Claims	Basis for Unpatentability
Ground 1	1-3, 9, 11-15	Obvious over Coulson-122, Badyal, and Cohen
Ground 2	1-8, 10-15	Obvious over Coulson-122, Badyal, and Holliday
Ground 3	1-4, 10, 12-15	Obvious over Coulson-122, Badyal, and Padiyath
Ground 4	1-3, 5-8, 11-15	Obvious over Coulson-122, Badyal, and Francesch
Ground 5	1-3, 5-8, 12-15	Obvious over Coulson-122, Badyal, and Tropsch

Because it presents excessive grounds without a reasonable justification, and relies on non-analogous art for 4 out of 5 grounds, the Petition should be denied.

Respectfully submitted,
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Dated: December 8, 2020

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FAVORED TECH CORPORATION,

Petitioner,

v.

P2I LTD.,

Patent Owner.

CASE: IPR2020-01198
Patent No. 10,421,876

**PETITIONER'S REPLY
TO PATENT OWNER'S PRELIMINARY RESPONSE**

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December 1, 2020

Petitioner disagrees with all proposed bases to decline institution in P2i's preliminary response (Paper 6) but recognizes that "evaluating statements or misstatements of the facts and law are well within the purview" of the panel. *Xactware Solutions, Inc. v. Pictometry Int'l Corp.*, IPR2016-00593, Paper 11 (PTAB July 1, 2016). Petitioner thus limited its requested reply to two issues: analogous art and redundancy. The Board authorized this reply by email on November 19, 2020.

Petitioner targeted those issues to address recent precedent on analogous art and to assist in parsing the '876 patent's labyrinthine claims against the non-redundant grounds in the petition. The Board should reject P2i's ill-founded assertions.

I. P2i misapplies the analogous art test in a way that contradicts recently issued Federal Circuit precedent and its own patent

P2i contends that four references are non-analogous art. Paper 6 at 41-48. That cannot be squared with *Donner Technology, LLC v. Pro Stage Gear, LLC*, 2020 WL 6554058 (Fed. Cir. Nov. 9, 2020), which issued after the preliminary response and refutes P2i's narrow approach, or with the '876 patent itself.

A reference is analogous art if (1) within the field of endeavor, or (2) reasonably pertinent to the problem with which the inventor is involved. *Donner*, 2020 WL 6554058, at *3; *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004). The references P2i disputes—Cohen, Holliday, Francesch, and Tropsch—are analogous art.

1. *Field of endeavor*. P2i's arguments here depend on limiting the field of endeavor to "plasma polymerized protective coatings," or even more narrowly to

“plasma polymerized coatings for electronic devices.” Paper 6 at 42, 45-47. But that framing runs contrary to the express teachings of the '876 patent.

Under “Field of the Invention,” the '876 patent broadly states: “This invention relates to protective coatings.” Ex. 1001 1:5. That section does not mention plasma polymerization, much less limit the relevant field solely to plasma polymerized coatings. *Id.* at 1:5-13. Similarly, the specification teaches that the invention may “advantageously” apply to electronics but “is of benefit in the context of a wide variety of substrates.” Ex. 1001 14:30-32. And the “Background of the Invention” cites two sources, neither of which fits the restrictions P2i seeks to impose: (i) WO 98/58117 described plasma polymers applied to many substrates other than electronics, Ex. 1001 1:19; Ex. 1022 at 8:6-12; and (ii) a cited 2005 article described polymer films for generic substrates applied without plasma polymerization, Ex. 1001 1:39-41.¹

“The field of endeavor of a patent is not limited to the specific point of novelty, the narrowest possible conception of the field, or the particular focus within a given field.” *Unwired Planet, LLC v. Google Inc.*, 841 F.3d 995, 1001 (Fed. Cir. 2016). P2i's efforts to limit the field solely to plasma polymerized coatings for electronics “contradict statements made in [its] own specification” and should not be credited.

¹ The Board directed that no evidence should accompany this reply; if permitted, Petitioner will submit the 2005 article as an exhibit for the Board's review.

In re Wood, 599 F.2d 1032, 1036 (CCPA 1979); *Wyers v. Master Lock Co.*, 616 F.3d 1231, 1238 (Fed. Cir. 2010). Cohen, Holliday, Francesch, and Tropsch are within the field—polymer coatings—of the '876 patent. Cohen described insulating polymers that could be applied as films and used to protect substrates like cables and electrical coils. Ex. 1006 2:60-63, 5:13-25. Holliday taught polymer coatings with mechanical, electrical, and chemical resistance properties. Ex. 1007 1:10-30, 2:39-50. Francesch described polymer coatings that provided improved solvent resistance. Ex. 1009 at 609-10. And Tropsch described methods and materials for polymer production, necessary aspects of any polymer-coating endeavor. Ex. 1011 2:13-6:25.

2. *Reasonable pertinence.* Even if P2i could limit the field of endeavor to plasma-polymer coatings for electronics, the cited art would be reasonably pertinent.

P2i collapses reasonable pertinence into the *same* narrow frame it presented to define the field of endeavor, limiting the asserted problems to creating “plasma polymerized protective coatings for electronic devices.” Paper 6 at 43-48. The Federal Circuit recently rejected that very approach. The correct analysis looks to the perspective of a POSA “resigned to considering art *outside her field of endeavor*.” *Donner*, 2020 WL 6554058, at *4 (emphasis added). P2i violates that premise by stating a purpose “so intertwined” with its asserted field of endeavor “that it would effectively exclude consideration of any references outside that field.” *Id.*

Moreover, P2i cites problems with tackiness, smearing, and contact angle

(Paper 6 at 42-43) that mismatch the claims and were already solved by known coatings. The '876 patent explains that such problems arose when using monomers with fewer than eight fluorinated carbons, like PFAC6. Ex. 1001 1:36-41, 1:47-2:4. But its claims are not so limited. *See, e.g.*, Claims 12-15 (reciting monomers with 8+ fluorinated carbons, including PFAC8). The '876 patent acknowledges that using PFAC8 at low power was known to yield stable, non-stick coatings with high contact angles. Ex. 1001 1:28-46. Those properties thus “could not possibly be a relevant purpose of the invention.” *Donner*, 2020 WL 6554058, at *4. Rather, the stated purpose related to achieving highly crosslinked coatings at low power. Ex. 1001 2:49-55. From the perspective of a POSA seeking to promote crosslinking, references describing known crosslinking agents, like Cohen, Holliday, Francesch, and Tropsch, “logically would have commended [themselves] to an inventor’s attention in considering his problem.” *In re ICON Health*, 496 F.3d 1374, 1380 (Fed. Cir. 2007).

II. The petition does not contain “excessive redundant grounds”

P2i briefly contends that institution should be denied due to redundant grounds. Paper 6 at 29. That assertion is both meritless and belied by the scattershot nature of its claims. Claim 1 alone spans approximately two columns of text, and as explained in the petition, recites crosslinkers of several different generic types. *See, e.g.*, Ex. 1001 18:54-19:57; Paper 1 at 32-33 (Formulas A, B1, B2). And various dependent claims separately limit each genus: claim 4 recites a subset of Formula B,

claims 5-8 limit Formula A, claim 9 requires B1 crosslinkers, and claim 10 recites a subset of type B2. Claim 11 lists a handful of particular species.

Multiple grounds were thus required to address all claimed crosslinkers, and there is not “significant overlap[]” as to the many dependent claims. Paper 6 at 29.

5 For example, Cohen taught DVTMDS, the only B1-type crosslinker in the asserted grounds. Paper 1 at 32-33, 40. Only Holliday and Padiyath described B2-type crosslinkers that could satisfy claim 10, and of those only Holliday's DCHD monomer also appeared in claim 11. *Id.* at 43-44, 51, 53-54. Francesch and Holliday described a Formula A crosslinker that also fits claim 11, *id.* at 43-44, 57-58, 63; only Tropesch
10 *expressly* described a Formula A crosslinker as in claim 8. *Id.* at 68, 50, 62-63.

Nor is this case comparable to *Adaptics*. The petition there asserted “and/or” grounds totaling anywhere from 17 to “hundreds of possible combinations” for just nine claims. The petition here challenges 15 claims with only five grounds, which is not unreasonable or burdensome, especially given the variety of crosslinkers in the
15 claims and the similar roles of Coulson-122 and Badyal in each ground. Moreover, references' relative strengths can depend “on the rebuttal arguments Patent Owner presents over the course of the proceedings.” *Niantic, Inc. v. Blackbird*, IPR2019-00489, Paper 8 at 9. For example, Holliday and Padiyath described B2-type crosslinkers, but only Padiyath was not challenged here on analogous art grounds. The
20 asserted grounds are not redundant, and the Board should institute IPR.

Dated: December 1, 2020

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