

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

QORVO, INC.,
Petitioner

v.

CORNELL RESEARCH FOUNDATION INC.,
Patent Owner

Case: IPR2024-00758
U.S. Patent No. 7,250,360

DECLARATION OF JOSEPH A. SMART, PHD

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Patent Trial and Appeal Board
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

I, Joseph A. Smart, PhD, hereby declare as follows:

1. I am a named inventor of U.S. Patent No. 7,250,360 (the “’360 Patent”).
2. I enrolled as a graduate student at Cornell University in 1995 in order to pursue advanced degrees in the Electrical and Computer Engineering department. I earned my Doctor of Philosophy (PhD) in Electrical and Electronics Engineering from Cornell University, and submitted my thesis to the graduate office in 2006. My thesis advisor was Professor James Shealy.
3. While at Cornell University in the 1990s, I did research on various topics, including techniques for growing gallium nitride (GaN) and other materials on lattice mismatched substrates such as silicon carbide (SiC), sapphire, and silicon (Si). I described much of this work in my 2006 thesis: Smart, J. A. (Joseph Allen). (2006). *High electron mobility transistor structures in the gallium arsenide and gallium nitride material systems by organometallic vapor phase epitaxy*. While looking for materials related to the ’360 Patent after being subpoenaed by Qorvo, Inc., I was able to locate a hard copy of that thesis in my records. I provided that hard copy to the lawyers at McKool Smith, and the thesis has been scanned and provided as Exhibit 2011 in this proceeding. I have reviewed the scanned version of Exhibit 2011 and it accurately reflects the contents of the hard copy of my thesis from 2006.

4. As part of the research Dr. Shealy and I did related to techniques for growing GaN and other materials on lattice mismatched substrates, we did a number of “epitaxial runs.” That is, we experimented with various techniques for wafer manufacturing to address then-existing issues related to structural and native defects that came about using other manufacturing techniques for growing GaN and other materials on lattice mismatched substrates. We performed these “runs” in a Cornell University lab. We documented these “runs” in run logs. In late May 2024, while continuing my search for material related to the ’360 Patent, I was able to locate several of these run log pages in a binder I stored in my records. I recall creating this binder in 1998 while working on a project with Dr. Shealy and others. The run log pages relate to various runs we did, and the binder includes images we generated for the semiconductor made using the corresponding run. I provided that binder to the lawyers at McKool Smith, and the binder has been scanned and provided as Exhibit 2013 in this proceeding. I have reviewed the scanned version of Exhibit 2013 and it accurately reflects the contents of my binder of materials from the late 1990s, that was in my custody since it was created until I provided it to the lawyers at McKool Smith.

5. I have been asked to provide some background on what is included in these run sheets. I will use “Run #iii333” as an example—on pages 19 and 20 of the PDF version of Exhibit 2013. This run corresponds with the “RUN # III333”

entry in Appendix B of my thesis. On the top of the first page of the run sheet, there are three items to note. Colored ovals are added to help call out each. First, there is a “Run #” in a magenta oval, which is the first thing we would write in a log entry. Second, there is a “date” in a yellow oval, which is the date the run was done. Third, there is an “operator” in a red oval, which is the person who ran the reactor. In this example, the “Run #” is iii333, the date we did the run was February 24, 1998, and the operator was me (JAS).

OMVPE III Run # Li1333 date: 2/24/98 operator: JAS

description: PATTERNED SUBSTRATES ELO Project.

Problems with Nit3 line between AlGaIn buffer
and GaN layer.

program used for this run: -MANUAL-

V/III ratio	growth segment	time	actual susceptor temp	TC temp	RF amps
7	to BAKE	10min			43.4
8	On Preflow	4min			44
900	AlGaIn Buffer (=6-7% Al)	30min			44
900	GaN Layer	40min			43
1800	AlGaIn cap layer (200-250Å)	2min			43

rotation speed: 0.1 cell press: 75 vent press: +1

zone I manifold temp: 525 OM3 heat tape: 590

NH3 cylinder: (left/right) start weight/press: 3396/95 psi heat tape voltage: 60V
finish weight/press:

	OM1	OM2	OM3	OM4	OM5	OM6
temp			301		164	
grams used			0			
mfcoffset			0.0		0.0	
Pres. closed			1.63		1.59	

wafer:

Diagram 1: Wafer cross-section showing growth segments: w/ plan s.c., w/ patterned s.c. 1st type, w/ patterned s.c. 2, w/ patterned s.c. 3, w/ plan s.c., w/ patterned s.c. 4, w/ patterned s.c. 5, w/ patterned s.c. 6, w/ patterned s.c. 7, w/ patterned s.c. 8, w/ patterned s.c. 9, w/ patterned s.c. 10, w/ patterned s.c. 11, w/ patterned s.c. 12, w/ patterned s.c. 13, w/ patterned s.c. 14, w/ patterned s.c. 15, w/ patterned s.c. 16, w/ patterned s.c. 17, w/ patterned s.c. 18, w/ patterned s.c. 19, w/ patterned s.c. 20, w/ patterned s.c. 21, w/ patterned s.c. 22, w/ patterned s.c. 23, w/ patterned s.c. 24, w/ patterned s.c. 25, w/ patterned s.c. 26, w/ patterned s.c. 27, w/ patterned s.c. 28, w/ patterned s.c. 29, w/ patterned s.c. 30, w/ patterned s.c. 31, w/ patterned s.c. 32, w/ patterned s.c. 33, w/ patterned s.c. 34, w/ patterned s.c. 35, w/ patterned s.c. 36, w/ patterned s.c. 37, w/ patterned s.c. 38, w/ patterned s.c. 39, w/ patterned s.c. 40, w/ patterned s.c. 41, w/ patterned s.c. 42, w/ patterned s.c. 43, w/ patterned s.c. 44, w/ patterned s.c. 45, w/ patterned s.c. 46, w/ patterned s.c. 47, w/ patterned s.c. 48, w/ patterned s.c. 49, w/ patterned s.c. 50, w/ patterned s.c. 51, w/ patterned s.c. 52, w/ patterned s.c. 53, w/ patterned s.c. 54, w/ patterned s.c. 55, w/ patterned s.c. 56, w/ patterned s.c. 57, w/ patterned s.c. 58, w/ patterned s.c. 59, w/ patterned s.c. 60, w/ patterned s.c. 61, w/ patterned s.c. 62, w/ patterned s.c. 63, w/ patterned s.c. 64, w/ patterned s.c. 65, w/ patterned s.c. 66, w/ patterned s.c. 67, w/ patterned s.c. 68, w/ patterned s.c. 69, w/ patterned s.c. 70, w/ patterned s.c. 71, w/ patterned s.c. 72, w/ patterned s.c. 73, w/ patterned s.c. 74, w/ patterned s.c. 75, w/ patterned s.c. 76, w/ patterned s.c. 77, w/ patterned s.c. 78, w/ patterned s.c. 79, w/ patterned s.c. 80, w/ patterned s.c. 81, w/ patterned s.c. 82, w/ patterned s.c. 83, w/ patterned s.c. 84, w/ patterned s.c. 85, w/ patterned s.c. 86, w/ patterned s.c. 87, w/ patterned s.c. 88, w/ patterned s.c. 89, w/ patterned s.c. 90, w/ patterned s.c. 91, w/ patterned s.c. 92, w/ patterned s.c. 93, w/ patterned s.c. 94, w/ patterned s.c. 95, w/ patterned s.c. 96, w/ patterned s.c. 97, w/ patterned s.c. 98, w/ patterned s.c. 99, w/ patterned s.c. 100.

Diagram 2: Wafer cross-section showing growth segments: w/ plan s.c., w/ patterned s.c. 1st type, w/ patterned s.c. 2, w/ patterned s.c. 3, w/ plan s.c., w/ patterned s.c. 4, w/ patterned s.c. 5, w/ patterned s.c. 6, w/ patterned s.c. 7, w/ patterned s.c. 8, w/ patterned s.c. 9, w/ patterned s.c. 10, w/ patterned s.c. 11, w/ patterned s.c. 12, w/ patterned s.c. 13, w/ patterned s.c. 14, w/ patterned s.c. 15, w/ patterned s.c. 16, w/ patterned s.c. 17, w/ patterned s.c. 18, w/ patterned s.c. 19, w/ patterned s.c. 20, w/ patterned s.c. 21, w/ patterned s.c. 22, w/ patterned s.c. 23, w/ patterned s.c. 24, w/ patterned s.c. 25, w/ patterned s.c. 26, w/ patterned s.c. 27, w/ patterned s.c. 28, w/ patterned s.c. 29, w/ patterned s.c. 30, w/ patterned s.c. 31, w/ patterned s.c. 32, w/ patterned s.c. 33, w/ patterned s.c. 34, w/ patterned s.c. 35, w/ patterned s.c. 36, w/ patterned s.c. 37, w/ patterned s.c. 38, w/ patterned s.c. 39, w/ patterned s.c. 40, w/ patterned s.c. 41, w/ patterned s.c. 42, w/ patterned s.c. 43, w/ patterned s.c. 44, w/ patterned s.c. 45, w/ patterned s.c. 46, w/ patterned s.c. 47, w/ patterned s.c. 48, w/ patterned s.c. 49

	Temp	Pressure	Comments	TEG (OM3)	NH3 zone1	NH3 black	Cell Throttle	Cell Throttle	HC (CO)
			2F on				4.9	12.9	3.7
		30A	Balance a				5.3	19.4	5.6
		30A	Washaway base				5.3	20.5	3.6
		100	TURN UP						
		100	EF.						
12:28	49.3	57.0	45A	CHARGED NH3					
	4.9			LINE					
12:30	105	103.5	45A	NH3 INVENT	2.9		4.8	52.1	2.9
	105			WASHAWAY					
12:30	105	103.5	45A	START BASE	3.1		4.8	55.1	3.1
				TEMP.					
	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
12:35	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
12:40	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
12:45	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
12:50	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
12:55	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:00	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:05	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:10	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:15	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:20	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:25	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:30	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				
13:35	75.1	100	44A	CHARGE	5.3				
	75.1	100	44A	CHARGE	5.3				

6. On the bottom half of the first page there are details about the run itself. Colored rectangles are added to help call out items I want to discuss. First, there is a table of “V/III RATIO” numbers in a magenta rectangle. For each listed

“growth segment,” this table lists the ratio of the amount of group V material (here, nitrogen) compared to the amount of group III material (here, gallium and aluminum). As can be seen in the table, there was no nitrogen being introduced during the “Om Preflow,” which is why there is a “0” in the table. Second, there is a list of “growth segment” steps and the duration of “time” of each step in a yellow rectangle. These “growth segment” steps and the “time” provide a description of the step and its duration, though more details are on the backside of the run log. Third, at the bottom and in a red rectangle, there is discussion of the “wafers” used for the respective run. For this particular run, we used both SiC and sapphire. We also used silicon wafers during some of our runs.

7. On the second page of the “Run #iii333” run log there are also three colored rectangles. The first rectangle is magenta, and reflects the time (here, formatted in military time) during which each step ran. The second rectangle is yellow, and describes two temperatures (both in Celsius). At times during our runs we used two temperature measurements. The top number here comes from a thermocouple that gave us an indirect measurement of the susceptor temperature (just behind the susceptor on the other side of a quartz sleeve). This thermocouple measurement was a safety factor to double check on the temperature. The bottom value comes from a pyrometer reading looking straight at the susceptor, which is reflective of the real growth temperature in the reactor. The third rectangle is red,

and provides “comments” on the step being performed, including materials used and not used.

8. Although my binder in Exhibit 2013 includes copies of only some of our run logs, details about the other runs are reflected in Appendix B of my thesis. I generated Appendix B of my thesis using original run log information. I have searched but have not been able to locate additional original run log pages at this time in 2024.

9. As reflected in Appendix B of my thesis, Dr. Shealy and I had our breakthrough as to the research at issue here on December 31, 1997. It was then that we had our first successful nucleation layer after an OM (organometallic) preflow prior to the nucleation layer growth. This is reflected in the “RUN #” “III304” in Appendix B of my thesis. After doing additional runs reflected in Appendix B of my thesis dated up to May 10, 2000, Dr. Shealy and I submitted an invention disclosure to Cornell University based on the work I have described. I recall reviewing and signing that document in late summer/early fall 2000. I have reviewed the document marked as Exhibit 2012, and I confirm it appears to be the invention disclosure I reviewed and signed in late summer/early fall 2000. Although I do not remember the specific date, the invention disclosure reflects my signing the document on October 5, 2000, which is consistent with my memory of the submission of this document to Cornell.

10. I hereby declare under penalty of perjury under the law of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1001.

Date: June 14, 2024

Respectfully submitted,



Joseph A. Smart, PhD