

Table B.2
(Continued)

Material	Modulus of Elasticity	
	GPa	10 ⁶ psi
Refractory Metals		
Molybdenum (commercially pure)	320	46.4
Tantalum (commercially pure)	185	27
Tungsten (commercially pure)	400	58
Miscellaneous Nonferrous Alloys		
Nickel 200	204	29.6
Inconel 625	207	30
Monel 400	180	26
Haynes alloy 25	236	34.2
Invar	141	20.5
Super invar	144	21
Kovar	207	30
Chemical lead	13.5	2
Tin (commercially pure)	44.3	6.4
Lead-tin solder (60Sn-40Pb)	30	4.4
Zinc (commercially pure)	104.5	15.2
Zirconium, reactor grade 702	99.3	14.4
GRAPHITE, CERAMICS, AND SEMICONDUCTING MATERIALS		
Aluminum oxide		
• 99.9% pure	380	55
• 96% pure	303	44
• 90% pure	275	40
Concrete	25.4–36.6 ^a	3.7–5.3 ^a
Diamond		
• Natural	700–1200	102–174
• Synthetic	800–925	116–134
Gallium arsenide, single crystal		
• In the <100> direction	85	12.3
• In the <110> direction	122	17.7
• In the <111> direction	142	20.6
Glass, borosilicate (Pyrex)	70	10.1
Glass, soda-lime	69	10
Glass-ceramic (Pyroceram)	120	17.4
Graphite		
• Extruded	11	1.6
• Isostatically molded	11.7	1.7
Silica, fused	73	10.6
Silicon, single crystal		
• In the <100> direction	129	18.7
• In the <110> direction	168	24.4
• In the <111> direction	187	27.1
Silicon carbide		
• Hot-pressed	207–483	30–70
• Sintered	207–483	30–70

Table B.2
(Continued)

Material	Modulus of Elasticity	
	GPa	10 ⁶ psi
Silicon nitride		
• Hot-pressed	304	44.1
• Reaction-bonded	304	44.1
• Sintered	304	44.1
Zirconia, 3 mol% Y ₂ O ₃	205	30
POLYMERS		
Elastomers		
• Butadiene-acrylonitrile (nitrile)	0.0034 ^b	0.00049 ^b
• Styrene-butadiene (SBR)	0.002–0.010 ^b	0.0003–0.0015 ^b
Epoxy	2.41	0.35
Nylon 6,6	1.59–3.79	0.230–0.550
Phenolic	2.76–4.83	0.40–0.70
Poly(butylene terephthalate) (PBT)	1.93–3.00	0.280–0.435
Polycarbonate (PC)	2.38	0.345
Polyester (thermoset)	2.06–4.41	0.30–0.64
Polyetheretherketone (PEEK)	1.10	0.16
Polyethylene		
• Low density (LDPE)	0.172–0.282	0.025–0.041
• High density (HDPE)	1.08	0.157
• Ultra-high-molecular-weight (UHMWPE)	0.69	0.100
Poly(ethylene terephthalate) (PET)	2.76–4.14	0.40–0.60
Poly(methyl methacrylate) (PMMA)	2.24–3.24	0.325–0.470
Polypropylene (PP)	1.14–1.55	0.165–0.225
Polystyrene (PS)	2.28–3.28	0.330–0.475
Polytetrafluoroethylene (PTFE)	0.40–0.55	0.058–0.080
Poly(vinyl chloride) (PVC)	2.41–4.14	0.35–0.60
FIBER MATERIALS		
Aramid (Kevlar 49)	131	19
Carbon		
• Standard modulus (PAN precursor)	230	33.4
• Intermediate modulus (PAN precursor)	285	41.3
• High modulus (PAN precursor)	400	58
• Ultra-high modulus (pitch precursor)	520–940	75–136
E-glass	72.5	10.5
COMPOSITE MATERIALS		
Aramid fibers-epoxy matrix ($V_f = 0.60$)		
Longitudinal	76	11
Transverse	5.5	0.8
High-modulus carbon fibers-epoxy matrix ($V_f = 0.60$)		
Longitudinal	220	32
Transverse	6.9	1.0
E-glass fibers-epoxy matrix ($V_f = 0.60$)		
Longitudinal	45	6.5
Transverse	12	1.8