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CORE COMPETENCY

Chemical vapor deposition of refractory and platinum group metals and ceramics for use in extreme thermal, chemical, and mechanical environments

2745 1500																	4275 1500
Be Beryllium																	B Boron
12 24																	13 27
Mg Magnesium																	Al Aluminum
20 40	21 45	22 48	23 51	24 52	25 55	26 56	27 59	28 59	29 64	30 65	31 70						
1797 1112	3104 5812	3162 1943	3682 5175	2645 2130	2335 1517	3135 1809	3187 1726	3021 1768	2836 1358	1180 693	2478 303						
Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium						
38 88	39 89	40 91	41 93	42 98	43 98	44 101	45 103	46 106	47 108	48 112	49 115						
1090 1044	3911 1209	4852 2129	4912 2061	5037 2740	4538 2473	4423 2623	3970 2260	3237 1826	2436 1234	1045 104	2346 300						
Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium						
56 137	57 139	72 178	73 181	74 184	75 187	76 190	77 192	78 195	79 197	80 201	81 204						
2171 1002	9730 1193	4876 2500	3731 2287	5838 3680	5869 3453	5188 3300	4761 2765	4106 2045	3130 1338	630 234	1746 377						
Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium						
88 226	89 227											Refractory Metals		Platinum Group Metals			
1809 973	3473 1323																
Ra Radium	Ac Actinium																

KEY POINTS OF CONTACT

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KEY PROJECTS OR PRODUCTS

- Freestanding refractory metal components
- Open-cell refractory metal and ceramic foams
- Ceramic and metal matrix composites
- Protective coatings
- Hypersonic materials

Key markets

Aerospace | Defense | Orthopedic implants | Energy

Applications

- Propulsion
- Thermal management at ultrahigh temperatures
- Structural thermal protection systems
- Heat sinks
- Ablators
- Insulators
- Cryogenic insulation and heat exchangers

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NASA Parker Solar Probe

2500 °F

85 °F
HEAT SHIELD

YES, THIS THIN!

Parker Solar Probe facing the Sun

Sun side: 2500 °F

4 1/2"

Payload side: 85 °F

STRUCTURAL CARBON FOAM

~8' diameter x 4 1/2"

97% void space ("air")

ULTRAMET
ADVANCED MATERIALS SOLUTIONS

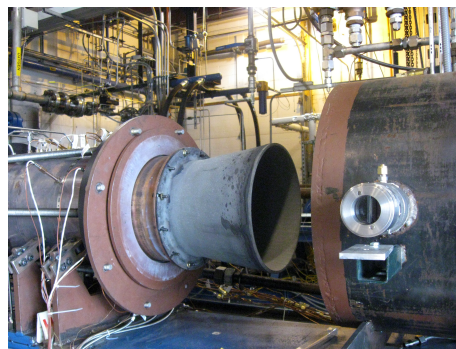
In space now—launched August 2018

“... the heat shield works so well that we had to put some of the heaters on for the instruments, even at closest approach.”

— NASA spokesperson briefing on performance of Parker Solar Probe in its first fly-by of the Sun, Nov 2018.



Iridium-lined rhenium combustion chambers for high-performance liquid rocket engines



Ultramet carbon foam forms the core of the heat shield on the Parker Solar Probe.