PLAVIS is...

a super engineering plastic. PLAVIS polyimide has a unique chemical structure with some of the highest properties available. Nitrogen bonded to 3 carbons is the critical part of the chain and imparts the plastic with remarkable features and benefits. DAELIM makes PLAVIS raw material all the way to the molded parts, plates, and rods. PLAVIS isostatic molded rods have uniform properties in all directions.

Properties

<table>
<thead>
<tr>
<th>01 Thermal</th>
<th>04 Wear and Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of the highest temperature plastics in the world with a continuous operating temperature of 300°C. Well suited for cryogenic conditions.</td>
<td>1 million psi-fpm PV limit with lubrication, 300,000 psi-fpm PV limit without lubrication. Stable friction level.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>02 Mechanical</th>
<th>05 Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retains high tensile strength and modulus even at high temperatures. Will not crack or creep under load.</td>
<td>Pure grade is an ideal electrical and thermal insulator. Filled grades can be tailored to application requirements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>03 Out-gassing</th>
<th>06 Machinability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest out-gassing of any plastic at 300°C. Will not contaminate vacuum chamber process or products.</td>
<td>Machines like brass-capable to make tiny and intricate features without cracking. Can be lapped to mirror finish.</td>
</tr>
</tbody>
</table>

Grades

<table>
<thead>
<tr>
<th>Grades</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAVIS-N</td>
<td>Non filled(N) Best physical properties, maximum electrical and thermal insulation, low out-gassing, superior radiation resistance.</td>
</tr>
<tr>
<td>PLAVIS-G15</td>
<td>Graphite 15wt% filled(G15) Self lubricating grade for wear and friction applications.</td>
</tr>
<tr>
<td>PLAVIS-G40</td>
<td>Graphite 40wt% filled(G40) Self lubricating grade with low thermal expansion.</td>
</tr>
<tr>
<td>PLAVIS-MS</td>
<td>MoS2 15wt% filled(M5) Self lubricating grade for vacuum environments.</td>
</tr>
<tr>
<td>PLAVIS-C</td>
<td>Conductive(C) Electrical conductive, high thermal resistance and superior mechanical properties. And surface resistivity $10^3$-10$^7$</td>
</tr>
<tr>
<td>PLAVIS-ESD</td>
<td>Electrostatic dissipative(ESD) Electrostatic dissipative, high thermal resistance and superior mechanical properties. And surface resistivity $10^3$-10$^7$</td>
</tr>
</tbody>
</table>
APPLICATIONS

01 FPD (Flat Panel Display)
- Drying oven (HP/CP, Baking, IR)
- Glass support pins, Glass holders, Rollers
- Cleaning
- EUV roller, Bearing
- PVD/CVD Insulation parts: Insert, Clamp, Bush, Caps, Susceptor pin, Ball bearing etc.
- Etcher: Screw, bolts.
- Others: Probe unit, station parts

02 Solar Cell
- Drying oven (HP/CP, Baking, IR)
- Glass support pins, Glass holders, Rollers
- Cleaning: EUV roller, bearing
- PVD/CVD Insulation parts: Insert, Clamp, Bush, Caps, Susceptor pin, Ball bearing etc.

03 Semiconductor
- Wafer Processing: Wafer clamp rings, Insulators, Screw & Fasteners, Vacuum pads, Alignment pins
- Wafer handling: Wafer guides, Wafer carriers, Vacuum pick up strips
- IC handling & testing: Die pick up collects, Test socket insulator

04 General Industry
- Hot runner system: Seal caps, Insulators
- Plasma cutting torches parts: Swirl rings, Insulator, Caps.
- Heat resistance materials: Bottle grippers, VConveyor tips
- Scientific consumable parts: GC/Mass ferrels, HPLC valve rotors
- Textile Machines: Valve seat, Bearing, Shedder Bushing

05 Automotive / Transportation
- Transmissions: Thrust Washers, Seal Rings, Valve Seats, Transmission Valve Balls, Check Valves
- Electrical Motors: Bushings, Washers, Thrust Plugs
- Brakes: Wear Pads, Valve Seats and Balls in ABS Systems
- Fuel Systems: Bushings, Seal Rings, Band Springs, Valve Seats
- Turbo Chargers: Ball Bearing Retainers, Wastegate Bushings
- Others: Vacuum Pump Vanes, Engine Belt Tensioners, Rubbing Blocks, Door Hinge Bushings, Gear Stick Rollers, Ignition Distributors, Constant Friction Pads for Split-Flywheels

06 Aerospace/Aircraft
THERMAL PROPERTIES

01  High Heat Resistance

The main feature of PLAVIS is that it has no melting point with a continuous operating temperature of 300°C. Even at 370°C, a 50% reduction in tensile strength will not occur for 200 hours for PLAVIS-N (neat), 220 hours for PLAVIS-G15 (15% graphite filled), and 360 hours for PLAVIS-G40 (40% graphite filled). In a vacuum or oxygen void environment, the heat resistance of PLAVIS is even higher.

Since PLAVIS has no melting point unlike other polyimides or thermoplastics such as PEEK, PAI, PEI; the strength vs. temperature of PLAVIS is very linear and predictable. For applications where part dimensions and tolerances are critical over a range of temperature, PLAVIS is an excellent.

![Comparison of continuous operating temperature of various ENPLA](Image1)

![Pyrolysis Temperature (TGA, in air)](Image2)

![Weight 50wt% Reduction Time (TGA, 520°C, in air)](Image3)

![Comparison of HDT with various Engineering Plastics (8264psi)](Image4)

![Comparison of Tg of various SUPER-ENPLA](Image5)

![Relations between Typical Tensile strength and Temperature of PLAVIS (ASTM-D1708)](Image6)

<table>
<thead>
<tr>
<th>Melting Point (Tm)</th>
<th>Heat Deflection Temperature</th>
<th>Thermal Decomposition Temperature (TGA, in air)</th>
<th>Thermal 50wt% Reduction Time (TGA, 520°C, in air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>360°C</td>
<td>614°C</td>
<td>239min</td>
</tr>
</tbody>
</table>

Table 1. PLAVIS Heat-Resisting Property

02  Thermal Expansion Property

Table 2 lists the thermal expansion coefficients of PLAVIS grades. The addition of graphite lowers the expansion level all the way to that of aluminum for PLAVIS G40 grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>PLAVIS-N</th>
<th>PLAVIS-G15</th>
<th>PLAVIS-G40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Expansion Coefficient (10^-6m/m°C)</td>
<td>5.5</td>
<td>4.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 2. Average Thermal Linear Expansion Coefficient of Plavis MP type
03 Inflammability

PLAVIS has a UL 94 listing as V0. It will not sustain a flame in air. The limiting oxygen index that indicates the minimum oxygen required for continual burning is 55% for PLAVIS-N, 54.15% for PLAVIS-G15, and 53.7% for PLAVIS-G40.

04 Low Out-gassing

PLAVIS does not degrade at high temperatures or give off volatiles or condensable gasses. In vacuum processing chambers for LCD or Electronics, PLAVIS is the only plastic that can replace ceramics and metals. PLAVIS meets the NASA specification for total mass loss in space vacuum environments for satellite applications.

FRICITION & WEAR PROPERTIES

PLAVIS graphite filled grades are self lubricating and can be applied to wear and friction applications such as bearings and wear strips even in high temperature oil/grease starved environments.

01 Friction

PLAVIS bearing grades operate at the highest temperatures of any plastics. No other polymer can operate at 300°C without oil or grease lubrication.
02 Wear

The friction level and wear rate of PLAVIS bearings quickly stabilize to uniform values. Temperature is an important factor for friction level of the graphite filled grades. Pure PLAVIS bearings are selected when low particle generation is required.

![Friction Coefficient vs Temperature (non-lubrication, 54°C)](image1)

**Picture 13.** Relations between friction coefficient and temperature (PLAVIS-G15)

![Typical wear curve of PLAVIS-G15 (vs carbon steel)](image2)

**Picture 14.** Typical wear curve of PLAVIS-G15 (vs carbon steel)

![Particle Count on running (PLAVIS-N)](image3)

**Picture 15.** Particle Count on running (PLAVIS-N)

### CHEMICAL STABILITY

PLAVIS has good resistance to many organic solvents, oils, and greases such as ATF (automatic transmission fluid). Even at high temperatures in these lubricants, the mechanical properties of PLAVIS are not significantly changed. PLAVIS should not be used in strong alkali conditions such as pH over 10. The chemical structure of PLAVIS is not resistant to bases.

### NEW GRADE PLAVIS-C & PLAVIS-ESD

01 Electrical Properties of PLAVIS-C&ESD

PLAVIS-C is the conductive polyimide. PLAVIS-ESD is electrostatic dissipative grade. PLAVIS-C & ESD show the uniform surface resistivity under the various input voltages.

![Surface resistivity of PLAVIS-C & ESD grades under the various input voltages](image4)

**Picture 16.** Surface resistivity of PLAVIS-C & ESD grades under the various input voltages

02 Applications

- Wafer handling
- Flat panel display glass handling process
- Electronics manufacturing line fixtures
- Bearing in electronic products and motors
- Burn in and test socket

![Out-gassing property of PLAVIS-C & ESD](image5)

**Picture 17.** Out-gassing property of PLAVIS-C & ESD
## Summary of Typical Properties of PLAVIS Polyimidide resin

<table>
<thead>
<tr>
<th>Property</th>
<th>Condition</th>
<th>ASTM Method</th>
<th>Unit</th>
<th>PLAVIS-N (DAELIM)</th>
<th>PLAVIS-G15 (DAELIM)</th>
<th>PLAVIS-G40 (DAELIM)</th>
<th>PLAVIS-MS (DAELIM)</th>
<th>PLAVIS-C (DAELIM)</th>
<th>PLAVIS-ESD (DAELIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>DF</td>
<td>ISO</td>
<td>CM</td>
<td>DF</td>
<td>ISO</td>
<td>CM</td>
<td>DF</td>
</tr>
<tr>
<td>Tensile Strength, ultimate</td>
<td>23°C</td>
<td>D-1708</td>
<td>Kgf/cm² (MPa)</td>
<td>810 (79.4) 900 (88.3) 900 (88.3)</td>
<td>650 (83.7) 680 (66.7) 680 (66.7)</td>
<td>550 (53.9) 580 (56.9) 580 (56.9)</td>
<td>600 (58.8) 650 (63.7) 650 (63.7)</td>
<td>650 (63.7) 700 (68.6) 650 (63.7)</td>
<td>650 (63.7) 700 (68.6)</td>
</tr>
<tr>
<td></td>
<td>260°C</td>
<td></td>
<td></td>
<td>400 (39.2) 420 (41.2) 420 (41.2)</td>
<td>320 (32.4) 350 (34.3) 350 (34.3)</td>
<td>270 (26.5) 280 (27.5) 280 (27.5)</td>
<td>400 (39.2) 400 (39.2)</td>
<td>750 (73.0) 750 (73.0)</td>
<td>750 (73.0) 750 (73.0)</td>
</tr>
<tr>
<td>Elongation, ultimate</td>
<td>23°C</td>
<td>D-1708</td>
<td>%</td>
<td>8.5 7.5 8.0</td>
<td>5.5 4.5 5.0</td>
<td>2.5 2.5 2.5</td>
<td>4.5 4.0 5.0</td>
<td>6.0 5.5 6.0</td>
<td>6.0 5.5 6.0</td>
</tr>
<tr>
<td></td>
<td>260°C</td>
<td></td>
<td></td>
<td>7.6 6.0 6.0</td>
<td>4.5 3.0 3.0</td>
<td>2.5 2.0 2.0</td>
<td>5.0 5.0 5.0</td>
<td>10 10 10</td>
<td>10 10 10</td>
</tr>
<tr>
<td>Flexural Strength, ultimate</td>
<td>23°C</td>
<td>D-790</td>
<td>Kgf/cm² (MPa)</td>
<td>860 (84.3) 1,150 (112.8) 1,150 (112.8)</td>
<td>850 (83.4) 1,100 (107.9) 1,100 (107.9)</td>
<td>650 (63.7) 900 (88.3) 900 (88.3)</td>
<td>780 (76.5) 800 (78.5) 800 (78.5)</td>
<td>1,100 (107.9) 1,100 (107.9)</td>
<td>1,100 (107.9) 1,100 (107.9)</td>
</tr>
<tr>
<td></td>
<td>260°C</td>
<td></td>
<td></td>
<td>470 (46.1) 600 (58.8) 600 (58.8)</td>
<td>500 (49.5) 650 (63.7) 650 (63.7)</td>
<td>400 (39.2) 450 (44.1) 450 (44.1)</td>
<td>400 (39.2) 450 (44.1)</td>
<td>750 (73.0) 750 (73.0)</td>
<td>750 (73.0) 750 (73.0)</td>
</tr>
<tr>
<td></td>
<td>260°C</td>
<td></td>
<td></td>
<td>(1,422) (1,667) (1,667)</td>
<td>(1,765) (2,550)</td>
<td>(2,746) (2,746)</td>
<td>(1,814) (1,863)</td>
<td>(1,814) (1,863)</td>
<td>(1,814) (1,863)</td>
</tr>
<tr>
<td>Compressive Strength @1% Strain</td>
<td>23°C</td>
<td>D-695</td>
<td>Kgf/cm² (MPa)</td>
<td>250 (24.5) 250 (24.5) 250 (24.5)</td>
<td>230 (22.6) 300 (29.4) 300 (29.4)</td>
<td>250 (24.5) 350 (34.3) 350 (34.3)</td>
<td>250 (24.5) 250 (24.5)</td>
<td>250 (24.5) 250 (24.5)</td>
<td>250 (24.5) 250 (24.5)</td>
</tr>
<tr>
<td></td>
<td>260°C</td>
<td></td>
<td></td>
<td>1,150 (112.8) 1,300 (127.5) 1,300 (127.5)</td>
<td>1,080 (105.9) 1,400 (137.3) 1,400 (137.3)</td>
<td>950 (93.2) 1,100 (107.9) 1,100 (107.9)</td>
<td>1,300 (127.5) 1,300 (127.5)</td>
<td>1,500 (141.7) 1,500 (141.7)</td>
<td>1,500 (141.7) 1,500 (141.7)</td>
</tr>
<tr>
<td>Compressive Modulus</td>
<td>23°C</td>
<td>D-695</td>
<td>Kgf/cm² (MPa)</td>
<td>24,500 (2,403) 24,000 (2,354) 24,000 (2,354)</td>
<td>23,500 (2,304) 30,000 (2,942) 30,000 (2,942)</td>
<td>27,000 (2,648) 34,000 (3,334) 34,000 (3,334)</td>
<td>25,000 (2,452) 25,000 (2,452) 25,000 (2,452)</td>
<td>25,000 (2,452) 25,000 (2,452)</td>
<td>25,000 (2,452) 25,000 (2,452)</td>
</tr>
<tr>
<td>Impact Strength, Iozd, notchet</td>
<td>23°C</td>
<td>D-256</td>
<td>Kg-cm/cm</td>
<td>6.0 6.0 5.0</td>
<td>5.0 5.0 5.0</td>
<td>5.0 5.0 5.0</td>
<td>5.0 5.0 5.0</td>
<td>5.0 5.0 5.0</td>
<td>5.0 5.0 5.0</td>
</tr>
</tbody>
</table>

### WEAR & FRICTION
- **Wear Rate**: m/s
  - 3.27x10⁻²
  - 3.27x10⁻²
  - 3.27x10⁻²
  - 3.27x10⁻²
  - 3.27x10⁻²
  - 3.27x10⁻²

### THERMAL
- **Coefficient of Linear Thermal Expansion**
  - 23°C to 260°C (μm/°C)
    - 50 50 55
    - 45
    - 25 25 50
  - 23°C to 260°C (μm/°C (°C/°C))
    - 0.34 0.32 0.32
    - 0.26 0.23 0.23
    - 0.18 0.16 0.16
    - 0.32 0.32

### ELECTRICAL
- **Dielectric Constant**
  - 23°C, @10¹² Hz
    - D-150
    - 3.75
- **Dielectric Strength**
  - D-149
    - 21.9
- **Volume Resistivity**
  - 23°C
    - D-257
    - 10¹² - 10¹⁴
    - 10¹⁴ - 10¹⁶
- **Surface Resistivity**
  - 23°C
    - D-257
    - 10¹⁰ - 10¹²
    - 10¹⁰ - 10¹²

### OTHER PROPERTIES
- **Water Absorption**
  - 50%RH (avg)
    - D-570
    - %
    - 0.9-1.1 0.9-1.1 0.9-1.1
  - **Specific Gravity**
    - D-792
    - g/cm³
    - 1.34 1.38 1.43
  - **Hardness**
    - D-785
    - Rockwell M
    - 70-90 85-100 90-105
  - **NOTICE:** Prior to use for any commercial purpose, the customer is fully responsible for determining its suitability for intended application and for ensuring its disposal practices are in compliance with applicable laws and other governmental enactments. DAELIM assumes no obligation or liability in this regard. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.
### ROD

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4&quot;</td>
<td>(6.35mm)</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>(9.53mm)</td>
</tr>
<tr>
<td>7/16&quot;</td>
<td>(11.11mm)</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>(12.70mm)</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>(15.88mm)</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>(19.05mm)</td>
</tr>
<tr>
<td>1&quot;</td>
<td>(25.40mm)</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>(31.75mm)</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>(38.10mm)</td>
</tr>
<tr>
<td>2&quot;</td>
<td>(50.80mm)</td>
</tr>
</tbody>
</table>

19.6"(500mm)

### PLATE

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;×12&quot;</td>
<td>(304.8mm×304.8mm)</td>
</tr>
<tr>
<td></td>
<td>12.7~62 (mm)</td>
</tr>
</tbody>
</table>