ALON® and Spinel Optical Ceramics

Surmet Corporation
31 B Street, Burlington MA 01803

For information contact:
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Tel: 781-272-3969
Email: sales@surmet.com
About Us

Surmet was founded in 1982 on the simple premise that today’s materials are not adequate to meet the challenges of tomorrow’s machines and systems. With over 30 years of successful operation, Surmet has demonstrated transition of its innovations from laboratory to production floor. Surmet became a leader in developing and manufacturing critical components such as the electrostatic clamp for semiconductor processing equipment. Surmet products have been inserted in IC Fabrication production lines used by all major companies worldwide.

In 2002 Surmet acquired ALON® Technology from Raytheon. Around the same time, Surmet developed its own production process for spinel, for military optics. ALON is harder, stronger, and more producible than spinel. However, spinel transmits further into the MWIR than ALON, making it the material of choice for certain applications. Surmet now offers windows, domes and lenses from both of these optical ceramics.

ALON® Transparent Armor offers state of the art performance against armor piercing threats at less than one-half the weight and thickness of conventional glass laminates. ALON armor solutions have been demonstrated for 30 and 50 Cal AP threats as well as for IEDs. Surmet produces 15x27-in ALON windows on a routine basis and is producing 18x35-in windows as well. ALON is already the most cost-effective transparent ceramic for armor applications. Surmet is supplying ALON layer to geometric specifications as well as ALON transparent armor per customers’ ballistic and environmental specifications.

For interest in receiving a quote for specific optical ceramic products, please send your inquiry to sales@surmet.com.

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Characteristics of ALON® Optical Ceramic

**Formability**
ALON is unique among extremely durable optical materials. Injection molding, slip casting and extrusion mean cost effective manufacturing

**Multispectral Transparency**
ALON is transparent from the UV to the mid-wave Infrared

**Durability**
ALON has a field life many times greater than conventional optical materials, providing significant life cycle cost savings

**Refractory**
ALON has a higher melting temperature than high purity alumina

**Chemically Inert**
ALON can withstand exposure to extreme environments including acids, bases and plasmas

ALON’s combination of properties and producibility make it ideal for many military and commercial applications.

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ALON® Optical Ceramic is an extremely durable crystalline material with excellent optical transparency in the near ultraviolet, visible and infrared up to approximately 5 µm wavelength.

The material combines mechanical and optical properties similar to sapphire with the advantages of an isotropic cubic crystal structure. It has an approximate composition of Al$_{23}$O$_{27}$N$_5$.

ALON® Optical Ceramic can be made to order as windows, domes, plates, rods and tubes in a wide range of sizes and thicknesses by a variety of conventional ceramic forming methods such as injection molding, isostatic pressing and slip casting. ALON® Optical Ceramic is fabricated using a proprietary powder processing technique.

**Composition**
- $\text{Al}_{23.3X}\text{O}_{27+X}\text{N}_{5-X}$
- $0.429<X<2$

**Average Grain Size**
- 200-300 microns

**Structure**
- Cubic, Spinel

**Lattice Constant**
- 7.956–7.936 Å

**Density**
- 3.69 g/cc

**Form**
- Polycrystalline

**Melting Point**
- 2150°C

**Young’s Modulus**
- 320 GPa

**Shear Modulus**
- 135 GPa

**Poisson’s Ratio**
- 0.24

**Hardness**
- 1800±100 kg/mm$^2$
  (Knoop indentation, 200g load)

**Fracture Toughness**
- 2.0MPa-m$^{1/2}$

**Flexure Strength**
- 300-700 MPa*

**Specific Heat**
- 0.22 cal/g°C

**Thermal Conductivity**
- ~12.6 W/mK (25°C)

**Transmission Limits**
- 0.22 to 6 microns

**Dielectric Properties**

<table>
<thead>
<tr>
<th>f (GHz)</th>
<th>k</th>
<th>$\tan \delta$ (x10$^{-5}$)</th>
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<tbody>
<tr>
<td>35-45</td>
<td>9.190</td>
<td>31</td>
</tr>
<tr>
<td>55-60</td>
<td>9.181</td>
<td>67</td>
</tr>
<tr>
<td>90-110</td>
<td>9.175</td>
<td>96</td>
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**Thermal Expansion Coeff.**

<table>
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<tr>
<th>T(°C)</th>
<th>TCE (x10$^{-6}$)</th>
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<tbody>
<tr>
<td>30-200</td>
<td>5.65x10$^{-6}$</td>
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<tr>
<td>30-400</td>
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<tr>
<td>30-600</td>
<td>6.93x10$^{-6}$</td>
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<tr>
<td>30-900</td>
<td>7.50x10$^{-6}$</td>
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**Index of Refraction**

<table>
<thead>
<tr>
<th>$\lambda$(µm)</th>
<th>n</th>
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<tbody>
<tr>
<td>0.48</td>
<td>1.03</td>
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<tr>
<td>0.50</td>
<td>1.01</td>
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<tr>
<td>0.64</td>
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<td>5.00</td>
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**IR Absorption Coefficient**

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<th>$\lambda$(µm)</th>
<th>$\alpha$ (cm$^{-1}$)</th>
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<tbody>
<tr>
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<td>5.102</td>
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<tr>
<td>5.319</td>
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Spinel Optical Ceramic

Technical Data

Composition \( \text{MgAl}_2\text{O}_4 \)
Form Polycrystalline
Lattice Constant 8.082 Å
Density*1 3.58 g/cc
Melting Point*1 2135°C

Grain Size (typical) Bimodal, 25 um average and 150 um average
Crystal Structure Cubic, Spinel
Young’s Modulus*1 276 GPa
Poisson’s Ratio*1 0.26

Thermal Expansion*1 \( 6.97 \times 10^{-6} \) (30-200 C)
Hardness*1 1650 kg/mm² (Knoop Indentation, 200g load)
Fracture Toughness*1 1.5 MPa-m\(^{1/2}\)
Flexure Strength*1 170 MPa
Specific Heat*1 0.8191 J/g - °C
Thermal Conductivity*1 25 W/m-C @ 25°C
Transmission Limits*1 0.25 to 6.5 microns
Typical Transmission
(@ 4 mm thickness)
76% @ 0.65 um
83% @ 1.064 um
82% @ 4.5 um

Ref. Index Homogeneity <5 x 10\(^{-6}\) over 3.0” diameter
(RMS) <9 x 10\(^{-6}\) over 4.7” diameter


### Index of Refraction

<table>
<thead>
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<th>( \lambda(\mu\text{m}) )</th>
<th>( n )</th>
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<td>3.00</td>
<td>1.6677</td>
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<tr>
<td>4.00</td>
<td>1.6386</td>
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<tr>
<td>5.00</td>
<td>1.598</td>
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</table>
Comparison of Transmission
(2 mm thick samples)

Spinel transmits out further than Sapphire, which transmits out further into the MWIR than ALON® Optical Ceramic.
Optical Ceramics Processing Steps

ALON® and Spinel Optical Ceramics are made by conventional ceramic processing techniques.

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IR Windows and Domes

ALON® Hyper-Hemisphere for Counter-Manpads

Reconnaissance Window

Spinel Lens

Spinel Tri-Mode Seeker Dome

ALON® and Spinel can be made in large sizes and more complicated geometries than Sapphire

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ALON® Transparent Armor
Defeats 50 Cal AP Threats

ALON® armor provides state-of-the-art protection at half the weight and thickness of conventional glass laminates.

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Rock Strike Durability 3x of Glass

ALON® Window

ALON® windows provide substantially higher durability in field than current glass windows

Note: Video of this test available upon request
Tiled ALON® Armor Windows

Tiled ALON® windows provide excellent ballistic performance
Engineered seams can be employed to minimize obscuration

![30 cal AP](image)

![50 cal AP](image)

Excellent multi-hit performance has been demonstrated against 30 cal and 50 cal AP rounds

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