MATERIALS FOR HIGH PERFORMANCE, RELIABLE RADOMES AND ANTENNAS
The Science of Communication

WORLD-LEADING RADOME COMPOSITE MATERIALS
Toray Advanced Composites is the world’s leading supplier of advanced composites and resin systems for the radome and antenna industry. Applications include use on radomes for military and civil aircraft, ship, rail, and ground-based systems, including conformal and patch antennas.

A radome (radar dome) is a cover designed to protect an antenna system from the environment, preserve vehicle aerodynamics, provide lightning strike protection, and maintain stealthy attributes. The optimum composite material is a crucial component of a reliable and highly functional radome antenna system.

In flight, it is not uncommon for a military aircraft to operate more than fifteen antennas with multiple functions such as weather detection, satellite communications (satcom), ground communication and imagery, target acquisition, fire control, jammer pods, altitude monitoring, and so on. Superior materials are required to ensure optimal output. Toray delivers optimal output in this complex signal environment.

TRENDS TOWARD HIGHER FREQUENCIES AND MULTIBAND COMMUNICATIONS
Antenna systems are increasingly multiband and multifunctional, operating “broadband” over a number of different frequencies, with trends toward higher frequencies. Not only are the lower frequency bands filling up, but operation at higher frequencies and multiple bands enables high data rates and nearly instantaneous exchange of “big data” packages. Airlines can send and transmit data enabling the “connected aircraft” in real time. Passenger streaming of video onboard is now feasible with Ku, K, and Ka-band communications.

Increased antenna system sophistication drives complexity in the radome design, requiring C-sandwich and B-sandwich constructions for satcom Wi-Fi radomes. Such complexity necessitates higher performance advanced materials such as cyanate ester/quartz, or epoxy/quartz prepregs in place of E-glass/epoxy.

Toray cyanate ester and epoxy prepregs, MicroPly™ syntactic and adhesive films, and RTM/infusion resin systems feature the low density, low dielectric constant and loss tangent, low moisture absorption, low coefficient of thermal expansion, and precise weight and thickness control needed to enable peak performance.

UNDERSTANDING DIELECTRIC CONSTANT AND LOSS
Signal attenuation, or dielectric loss, occurs either through absorption of electromagnetic energy resulting in matrix heating or by reflection of the signal from the surface or within the composite.

The dielectric constant (\(\varepsilon_r\)) gives an indication of the reflective and refractive properties of a material. Simplistically, the signal can be thought of as slowing down as it travels through the composite (compared with air). When the signal hits a surface at an angle, it is deflected. This deflection is referred to as “boresight error” or “beam deflection.”

Dielectric constant and loss determine the transmission efficiency of a radome/antenna system and are best measured at the intended operating frequencies. Lower dielectric constant and loss permit the antenna system to operate at lower power and minimizes the effect of the radome on antenna performance. Toray Advanced Composites has an extensive database of materials tested over many different frequencies to facilitate radome design. This data when input into computer-aided electromagnetic modeling packages is a powerful tool to help determine the performance of a proposed radome/antenna system design.

<table>
<thead>
<tr>
<th>BEST PERFORMANCE</th>
<th>BEST COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Performance</td>
<td>Cyanate Ester / Quartz Fabric</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>BEST</td>
</tr>
<tr>
<td>3.2 to 3.35</td>
<td>Low Tangent 0.001 to 0.009</td>
</tr>
<tr>
<td>Laminate Impact Strength</td>
<td>VERY GOOD</td>
</tr>
<tr>
<td>Laminate Moisture Absorption</td>
<td>LOWEST 0.1–0.6%</td>
</tr>
</tbody>
</table>

HF VHF UHF L S C K KKK V W
U.S. INDUSTRY STANDARD BANDS (IEEE Radar designation)

Photo courtesy of US Department of Defense
Photo courtesy of General Atomics Aeronautical Systems
Photo courtesy of US Dept of Defense
## ANTENNA AND RADOME MATERIALS

### Product Overview

#### TORAY COMPOSITE LAMINATE PERFORMANCE OVER C/X, KU/K, KA, AND Q/U BANDS

<table>
<thead>
<tr>
<th>Product Name(^1)</th>
<th>Resin Matrix</th>
<th>Dry Tg Onset</th>
<th>Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTCy-2 Cyanate Ester</td>
<td>191°C (375°F)</td>
<td>4581 Quartz N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>BTCy-1A Cyanate Ester</td>
<td>203°C (405°F)</td>
<td>4581 Quartz</td>
<td>3.26 (0.004)</td>
</tr>
<tr>
<td>EX-1515 Cyanate Ester</td>
<td>174°C (348°F)</td>
<td>4581 Quartz</td>
<td>3.24 (0.005)</td>
</tr>
<tr>
<td>TC522 Modified Cyanate Ester</td>
<td>180°C (356°F)</td>
<td>4581 Quartz</td>
<td>3.38 (0.004)</td>
</tr>
<tr>
<td>BTCy-2 Cyanate Ester</td>
<td>211°C (412°F)</td>
<td>4581 Quartz</td>
<td>3.26 (0.008)</td>
</tr>
<tr>
<td>TC420 Cyanate Ester</td>
<td>345°C (653°F)</td>
<td>4581 Quartz</td>
<td>3.36 (0.003)</td>
</tr>
<tr>
<td>EX-1522 Cyanate Ester</td>
<td>180°C (356°F)</td>
<td>4581 Quartz</td>
<td>3.45 (0.002)</td>
</tr>
<tr>
<td>TC522 Modified Cyanate Ester</td>
<td>191°C (375°F)</td>
<td>7781 E-glass</td>
<td>3.48 (0.001)</td>
</tr>
<tr>
<td>BTCy-1A Cyanate Ester</td>
<td>203°C (405°F)</td>
<td>4581 Quartz</td>
<td>3.28 (0.004)</td>
</tr>
<tr>
<td>EX-1522 Epoxy</td>
<td>180°C (356°F)</td>
<td>4581 Quartz</td>
<td>3.34 (0.005)</td>
</tr>
<tr>
<td>TC250 Epoxy</td>
<td>180°C (356°F)</td>
<td>4581 Quartz</td>
<td>3.45 (0.013)</td>
</tr>
<tr>
<td>TC522 Modified Cyanate Ester</td>
<td>191°C (375°F)</td>
<td>7781 E-glass</td>
<td>3.48 (0.001)</td>
</tr>
<tr>
<td>BTCy-1A Cyanate Ester</td>
<td>203°C (405°F)</td>
<td>4581 Quartz</td>
<td>3.28 (0.004)</td>
</tr>
<tr>
<td>EX-1543 Cyanate Ester</td>
<td>191°C (375°F)</td>
<td>4581 Quartz</td>
<td>3.34 (0.005)</td>
</tr>
<tr>
<td>TC250 Epoxy</td>
<td>180°C (356°F)</td>
<td>4581 Quartz</td>
<td>3.45 (0.013)</td>
</tr>
</tbody>
</table>

### COMMON PREPREG REINFORCEMENTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Service Temp.</th>
<th>Maximum Specific Gravity (g/cm(^3))</th>
<th>Moisture Pickup (g/100g)</th>
<th>Maximum Service Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-glass</td>
<td>6.10 (100)</td>
<td>0.004</td>
<td>2.55</td>
<td>nil</td>
</tr>
<tr>
<td>S-glass</td>
<td>5.21</td>
<td>0.006</td>
<td>2.49</td>
<td>nil</td>
</tr>
<tr>
<td>Quartz</td>
<td>3.78</td>
<td>0.0002</td>
<td>2.20</td>
<td>nil</td>
</tr>
<tr>
<td>HDPE</td>
<td>2.00</td>
<td>0.0004</td>
<td>0.97</td>
<td>nil</td>
</tr>
<tr>
<td>LMR Kevlar(^4)</td>
<td>3.85</td>
<td>0.008</td>
<td>1.47</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

\(^1\) SF-5 tested at 18 GHz
\(^2\) Open Resonator results using ASTM D 2520 Method C
\(^3\) Shorted waveguide results using test ASTM D 2520 Method A
\(^4\) LMR Kevlar\(^4\) is a Toray proprietary Ultra-Mattress Regain treatment of the aramid fabric from E.I. du Pont de Nemours and Company.
TECHNOLOGICALLY ADVANCED TRIBAND SATCOM RADOME

The General Dynamics LiveTV radome is a technologically advanced composite satcom radome. Designed to transmit data across three bandwidths (K, Ku, and Ka), the radome achieves enhanced levels of speed and connectivity for inflight Wi-Fi and two-way communication.

Toray Advanced Composites worked in partnership with General Dynamics, the radome designer and manufacturer, to provide the Toray TC250 material solution, allowing the enclosed antennas to transmit and receive radio frequency signals across a broader range of bandwidths. Other design considerations included consistency in signal transmission across all parts, longevity, and cost-effectiveness.

Toray TC250 is an epoxy-based thermoset prepreg that offers an outstanding balance of toughness, low dielectrics, mechanical property translation, and hot/wet performance. Combined with a quartz fabric, this advanced composite material solution provides excellent electrical and mechanical performance while maintaining cost-effectiveness.

LEARN MORE ABOUT THE USE OF OUR PRODUCTS IN RADOME ANTENNA SYSTEMS

Find this case study, and more at www.toraytac.com/success-stories

MANUFACTURING FACILITIES

Toray Advanced Composites has over 25 years of experience producing materials for radomes. Even a small carbon fiber contaminant in a radome will heat up in response to an electromagnetic signal, degrading the surrounding matrix with potentially disastrous results. To prevent this, Toray produces our dielectrically sensitive materials in enclosed positively-pressurized rooms with separate air systems and filters, housing carbon-free machines and equipment dedicated solely to the production of radome prepregs and complementary products. Our carbon-free facilities never see a carbon fiber material and are isolated from conductive materials, ensuring superior quality and electrically pure products.

Toray Advanced Composite materials from the carbon-free lines are used worldwide in antennas, reflectors, conformal radomes, components with embedded deicing elements, sonar domes, and microwave transparent and radar absorbing structures. Popular reinforcements such as E-glass, S2-glass, quartz, aramid, HDPE, and HDPP are fully compatible with Toray’s advanced resin systems and can be supplied as prepregs, adhesive, and syntactics to satisfy the most demanding electrical, mechanical, and high-temperature applications.

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the Toray TAC Product Selector
www.toraytac.com
Go to our online resource center for case studies and technical papers

More in-depth technical product data may be available. Please contact your Toray Account Manager or a member of the Expert Services team for more information.

To learn more about the fabrication of the General Dynamics LiveTV multiband satcom radome that is used by commercial airlines to bring Wi-Fi to passengers, read the High Performance Composites article at www.toraytac.com titled "Composites Aid Connectivity for Commercial Aircraft."
LOCATIONS AND CAPABILITIES

SOLUTIONS
- Thermoplastic composites
- Thermoplastic laminates
- Thermoset composites
- Carbon-free manufacturing
- Parts manufacture
- Sales office

CERTIFICATIONS
- ISO 9001:2015
- AS9100D

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