OBJECTIVE: Develop a new, environment-friendly, wide spectral band (from visible to mid wave infrared (IR)), high optical transmission (> 99.9% near IR) band, and high strength hydrophobic, greater than 12-inch diameter) submarine beam director head window materials.

DESCRIPTION: The Navy requires an innovative material solution for new large aperture (greater than 12 inch in diameter) and wide spectral band (broadband) optical development for High Energy Laser (HEL) beam director head window with anti-reflection coating (ARC) and water shedding or hydrophobicity ability. At present, there is no large aperture broadband head window with anti-reflection coating (ARC) and water shedding or hydrophobicity available. The head window shall be broadband (0.5 to 5 µm) and high strength with a greater than 99.9% transmission at near IR wavelength. The bandwidth of the material shall be within greater than 80% - both in visible and MWIR band. The head window shall also have near broadband (visible to MWIR) ARC, water-shedding (hydrophobicity), non-fouling and service life performance of the HEL beam director head windows (or imaging windows).

Residual water (seawater, rain) on a small craft operation near the marine wave boundary layer head window will lead to the delivery of the HEL optical power at greater than 100 kW with less than 0.1 percent total loss at HEL pass band. The proposed head window shall withstand static pressure equal or greater than the current fused silica window (thickness 3 inch), the head window material used in submarine imaging system window. Removing or shedding water fully and completely is critical to the successful operation of the beam director system. In addition, HEL beam director head windows are affected by micro fouling, which is currently one of the prime causes of reduced water shedding performance or hydrophobicity of the head window material.

The Navy needs an innovative approach to develop broadband large aperture window materials. The proposed window shall have broadband anti reflection (AR) coating and hydrophobicity, with a contact angle greater than 130°, with a goal of greater than 150°. The optical transmission of the window at near IR wavelength shall be greater than 99.9 percent, at visible and 0.5-µm wavelength with 90% transmission, including any absorption and scattering from the optical surface. The window random anti reflection (RAR) coating shall be able to withstand HEL power greater than 100kW. The proposed HEL window material shall have superior hydrophobicity and micro fouling or performance against salt sedimentation, which are major causes of any degradation, by no more than 10 percent during 15-year life of the head window. In addition, the window materials should be capable of being cleaned using normal maintenance and cleaning procedures without causing damage to the hydrophobicity of the surface or AR coating. The window materials shall survive in an environment including temperatures from -40°C to 60°C, thermal shock (hot air at +80°C to warm water at +50°C and cold air at -54°C to cold water at 10°C), severe icing, and ultra violet (UV) sunlight. The broadband large aperture beam director head should have RAR and IR coating and hydrophobicity technology that meets the above requirements and can, in addition, be applied to other types of HEL beam director head window materials such as sapphire, spinel, and aluminum oxynitride (referred to as ALON).

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no
Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Security Service (DSS). The selected contractor and/or subcontractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for new and innovative materials for wide spectral band large aperture beam director head windows. Conduct a feasibility study to demonstrate the viability of the proposed broadband high transmission materials with RAR coating through modeling and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop the window material, ensuring that the materials will support RAR, hydrophobic, non-fouling technology. Develop large aperture window materials for HEL application. Document the results and demonstrate the feasibility of the manufacturing concepts. Identify suitable candidate materials (e.g., sapphire, spinel, and ALON), low transmission loss (less than 0.1%) processes at 1 µm, and transmission higher than 90% (both in 0.5 and 5 µm spectral band). Ensure that the concept highlights process techniques to improve HEL beam director head window hydrophobicity and RAR. Propose the selection of a final material for window materials and AR coating and hydrophobicity technology candidate(s). Develop and deliver a large aperture (12 inches diameter) low transmission loss (at 1 µm, > 99.9%), hydrophobicity and AR coating material test coupon to the Navy lab to carry laser power (less than 100kW), environmental and stress test. Characterize the head window service life and determine service life protocols (e.g., service life, in-service maintenance) for the developed AR coating on actual head window materials. Develop a Phase III plan. It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL-USE APPLICATIONS: Support the Navy in transitioning the technology for operational use. Manufacture the successful materials, hydrophobicity, and coating based on the mechanical and environmental contraints of the HEL beam director.

This technology can be used in commercial airlines and satellite imaging systems.

REFERENCES:


KEYWORDS: Electro-Optics; Hydrophobic; Hydrophobicity; Non-Fouling; Non-Hazardous; Marine Wave Boundary Layer; MWBL; High-energy Laser Beam Director; HEL