Focus on an Innovator Who Develops Solutions to Technology Challenges

By DON Innovation

Advances in materials research traditionally relied heavily on the use of novel materials or novel composite ratios to customize material interaction with electromagnetic waves. In the past 20-30 years there has been increasing emphasis on theoretical and experimental investigations of subwavelength scale structuring of existing materials in pursuit of engineering material properties. Advances in computational power and lithography accuracy/scale have allowed for the rapid expansion of a class of materials called metamaterials which capitalize on structuring within the material to produce novel properties. Zachary Sechrist, Ph.D., has been applying these metamaterial concepts to multiple Navy specific problems while serving at Naval Air Warfare Center Weapons Division, China Lake in California.

NAVAIR Seal

Dr. Sechrist worked with small research teams with member diversity in both discipline areas and career stages to explore basic research solutions for Navy materials needs. This diverse background approach improved the identification and appreciation of solution virtues/limitations, allowed for natural growth of a solution within the intersection of the fields from contributing members, and paved the path for multiple collaborations that have now spun off into additional basic materials research and applied research closer to the warfighter.

The efforts under focus for this article are basic research projects examining solutions that may not transition products to warfighters for many years, but generate a deep understanding of the system being studied and illuminate the military potential for further investigation. Basic research investigations are inherently high risk, but can deliver an asymmetric advantage for U.S. Naval forces against adversaries that rely on commercial products.

In keeping with the Navy’s history of technological innovation, Dr. Sechrist was instrumental in the development of the following initiatives:

1. Counter Directed Energy Weapon (CDEW) Window Team:
Zachary Sechrist, Chris Yelton, Mark Moran, and Linda Johnson. This project examined a tunable Global Positioning System (GPS) window to protect GPS electronics from a fast rise Directed Energy (DE) attack. The solution was a novel low cost active metamaterial that could sense and react to electric field strengths large enough to do damage to underlying GPS electronics. The metamaterial used a geometry based nonlinear filter that shifted a pass band as a function of the field strength. The window was designed to

transmit low power GPS signals, but become opaque in the presence of large electric fields that would be generated under a directed energy attack.

2. Bulk Fabrication of Asymmetric Inorganic Nanostructures Utilizing Atomic Layer Deposition in a Fluidized Particle Bed Team:
Zachary Sechrist, Gretchen Hawes, and Joseph Clubb. Project examined a lithography and deposition process that produced inorganic structures that could capture solar radiation to drive localized chemical reactions: e.g. fuel generation or chemical/biological abatement. This project examined a novel vapor deposition process to produce bulk quantities of asymmetric structures with high reproducibility. The process had the capacity to produce large volumes of uniform asymmetric cups with low mass density and high surface/edge densities that are advantageous for photocatalysts.

3. Reconfigurable Metamaterial Using Etchable Glass Team:
Zachary Sechrist, Ronald Tonucci, Denise Canadas, and Gretchen Hawes This project investigated an engineered spectral response metamaterial that would undergo a non-reversible transition when exposed to a specific etchant. The spectral response of the metamaterial was shown to be reconfigurable using both liquid and gas etchants. After reconfiguration, an optical device incorporating the metamaterial would be permanently inoperable.

4. µRFID (Radio-Frequency Identification) Taggant Team:
Zachary Sechrist, Ronald Tonucci, and Joseph Estevez The project studied an identification marker that eliminated circuitry and power sources of traditional RFID chips to reduce size and sensitivity towards heat, shock and shelf life. The taggant was a resonator, or an array of resonators, that transformed a source waveform into a modified waveform from that incident upon it. The waveform modification was defined by the resonator structure, and spectral content contrast between the input and output waveforms improved the signal-to-noise ratio from the taggant.

The projects all used energy confinement in subwavelength structures to generate novel material solutions that could not be found using traditional material solutions. Dr. Sechrist's teams used electromagnetic modeling and simulation tools to design and optimize structures for weeks to months for each iteration of a device. The research teams then fabricated and tested the metamaterials equipment using optical and RF characterization. This metamaterial approach to answer Navy needs provided novel material solutions, created interagency collaborations, developed several young Navy researchers, and has transitioned into several ongoing projects.

Dr. Sechrist demonstrated persistence, passion, and vision in his pursuit of these materials solutions. He believes that U.S. military superiority in future engagements will stem from a combination of both rapid response projects that utilize off the shelf devices benefitting from mass market competition and the basic research niche projects that create asymmetric material advantages for U.S. Naval forces. Dr. Sechrist is proud of the materials invented, the warfare center capabilities developed, and the team growth that was made possible through these efforts.