Enabling High Performance Detectors And Optics For Astronomy And Planetary Exploration With ALD

April D. Jewell[1], John Hennessy[1], Frank Greer[1], Erika Hamden[2], Michael Hoenk[1] and Shouleh Nikzad[1]
[1]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA*
[2]*Department of Astronomy, Columbia University, New York, NY, USA*

Here we describe the use atomic layer deposition (ALD) for the development of antireflection coatings and pass band filters for silicon-based detectors, reflective coatings for optics, as well as surface passivation layers for a variety of semiconductor-based technologies. ALD is a technique whereby thin films are grown a monolayer at a time through a series of self-limiting chemical reactions at a substrate surface; thus, ALD offers nanometer-scale control over film thickness and properties.

In an ongoing project at the Jet Propulsion Laboratory (JPL), optical thin-films are incorporated with existing detector technologies to reduce reflection and allow more efficient absorption of desired spectral band. We have used plasma enhanced (PE) ALD to grow films on a variety of substrates, including live imaging devices. Based on this work we are able to achieve precision growth of optically relevant films and provide tailored, repeatable performance targeted for specific applications.

We have designed antireflection coatings for challenging parts of the spectrum and have deposited these coatings using PEALD directly onto the illumination surface of imaging arrays. Quantum efficiency (QE) measurements on these ALD-coated devices match modeled film behavior remarkably well, showing improved performance at the targeted wavelengths and bands. Examples for PEALD coatings designed to enhance QE for a variety of spectral ranges will be discussed. Broadband targets include 320-1000 nm, 500-1000 nm, and 300-600 nm; while narrower band benchmarks focus on improved QE for 100-200 nm, 200-235nm and 240-300 nm. With more complex coatings, it is possible to obtain QE's >80% in certain regions of the spectrum. The work described here marks a significant advancement in detector technology and capability.

In addition to antireflection coatings, out-of-band rejection filters can be designed and integrated with detectors. Integrated filters eliminate the need for the additional structural support of an external filter; eliminate the need for the lossy substrates on which external filters are constructed; imply fewer optical surfaces and eliminate the 2–3% minimum loss associated with each; and are more robust than the fragile and bulky external filter technologies. Integrated designs also provide the opportunity for improved system designs with enhanced efficiencies. We will discuss our design and latest results in this effort.

Similar films can be used to enhance reflectivity of optical surfaces to allow for design of more efficient systems. ALD techniques that can be extended to other technologies will also be discussed.