**Processing, structure and properties of thick CrN and $Cr_2N$ coatings deposited using Modulated Pulse Power (MPP) magnetron sputtering**

Jianliang Lin[1], John J Moore[1], William D Sproul[1,2], Sabrina Lee[3]

[1]Advanced Coatings and Surface Engineering Laboratory (ACSEL), Colorado School of Mines, Golden, Colorado, 80401, USA

[2] Reactive Sputtering, Inc, 2152 Goya Place, San Marcos, California, 92078 USA

[3] US Army ARDEC Benet Labs, Watervliet, NY 12189 USA

**Abstract:**

As a variation of high power pulsed magnetron sputtering (HPPMS) technique, Modulated pulse power (MPP) magnetron sputtering can achieve a high deposition rate while at the same time achieving a high degree of ionization of the sputtered material with a low ion energy. These advantages of the MPP technique can be utilized to obtain dense coating with a small incorporation of the residual stress and the defect density for the thick coating growth. In this study, the MPP technique was utilized to reactively sputtering thick $Cr_2N$ and CrN coatings (10- 55 μm) on different substrate materials (including AISI 304 stainless steel, 440C tool steel, cemented carbide, Cu, and Al-Si compound) in a closed field unbalanced magnetron sputtering system. High deposition rates of 15 and 10 μm per hour have been obtained for the $Cr_2N$ and CrN depositions using a 3 kW average target power, a 50 cm substrate to target distance and an $Ar/N_2$ gas ratio of 3:1 and 1:1 respectively. The coatings exhibited an increase in the scratch critical load as the thickness was increased. The compressive residual stress in the CrN coatings increased from 2.1 to 5.4 GPa as the coating thickness increased from 2.5 to 30 μm, but for thicker coatings the stress decreased as the coating thickness increased. The hardness of the coatings generally decreased with an increase in the coating thickness. However, thicker CrN coatings (above 10 μm) resulted in a significant improvement in the wear resistance. It was also found that the CrN coating exhibited higher adhesion strength and wear resistance than the $Cr_2N$ coating with the same coating thickness.