

HPPMS/HIPIMS Technology at the School of Mines

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High Power Pulsed Magnetron Sputtering or High Power Impulse Magnetron Sputtering (HPPMS/HIPIMS) is a relatively new technology. It was introduced to the world by Dr. Vladimir Kouznetsov in 1999 in Sweden, and it quickly spread to England, Germany, the Czech Republic, the USA, and other countries. The main advantage of the Kouznetsov form of HPPMS is that it can produce a highly ionized flux of sputtered material without macroparticles. Instead of having mainly neutral atoms arriving at the substrate, now ions, created by charge exchange mechanisms occurring between the sputtering target and the substrate, are used to build the coating on the substrate. With many more ions arriving at the substrate compared to the number of neutral atoms, dense well-adhered films can be deposited using relatively low substrate bias voltage, lowering the residual stress in the films. If the residual stresses are lower, thicker films can be deposited, which in many cases will lead to enhanced performance of the coated component.

As good as the Kouznetsov approach to HPPMS is in producing an ionized flux of coating material, there is one problem with it from an industrial standpoint. There is a significant reduction in the deposition rate for an equivalent average power compared to conventional dc magnetron sputtering. Fortunately Dr. Roman Chistyakov invented an alternative form of HPPMS now known as Modulated Pulse Power (MPP) that overcomes the rate issue while still producing a very high degree of ionization of the sputtered material. In fact, it has been shown for many materials that the deposition rate for MPP HPPMS for an equivalent average power can be up to two times higher than the dc rate. In addition, lately there have been reports of overcoming the rate problem using the Kouznetsov form of HPPMS when modifications have been added to the overall system.

We at the Advanced Coatings and Surface Engineering Laboratory (ACSEL) at the Colorado School of Mines have been very interested in HPPMS since its inception. With the lab's history in developing tribological coatings, we felt that HPPMS would be an excellent addition to the capabilities of the lab. ACSEL now has an opposed cathode, closed field unbalanced magnetron sputtering system with MPP HPPMS capabilities. As far as we know, we are the only lab in the USA that has such equipment, and it is our goal to make it the center for HPPMS development in the USA. It will be an open facility for all who want to get involved in the HPPMS technology. Examples of some of the ACSEL MPP deposited coatings will be discussed.