

## High Temperature Materials Laboratory User Program

### Characterization of Novel Coatings

#### Background

C3 International, LLC (Alpharetta, GA), has developed a proprietary coating material and process for extending the life of tooling used in aluminum die casting, high-speed machining, and metal stamping, based on technology licensed from the former Soviet Union.

For cutting tools, C3 coatings have been shown to dramatically increase wear resistance, extending tool life and increasing tool performance. However, the scientific reasons for these dramatic improvements are not well understood. To this end, researchers from C3 visited the High Temperature Materials Laboratory (HTML) to perform characterizations.

#### The Technology

The C3 process is a surface infusion treatment using selected rare earth metals in a carrier liquid (carboxylic acids), applied to metals and other materials and heated to a specific temperature (400 to 500°C).

At the HTML, researchers examined the coatings via X-ray diffraction (XRD) and scanning Auger microanalysis (SAM). XRD provides information about the crystalline nature, if any, of the coating. In this case, crystalline zirconium oxide ( $ZrO_2$ ) was observed and found to have a pseudo-cubic crystal structure with a 3-nanometer “crystallite” size. SAM provides information about the composition of the coating as a function of depth. SAM found that the C3 coating contained the elements zirconium, oxygen, and carbon and was nominally 225 nanometers thick.

#### Future Direction

Further studies are under way to determine what role carbon plays and also whether there is a significant variation in zirconium/oxygen/carbon composition through the film.



*Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle*



*H-13 steel die pins removed from same mold. The untreated (left) and treated (right) pins after 3,500 and 200,000 shots of aluminum, respectively.*

*vehicle systems*

*fuels & lubricants*

## Where Can I Find More Information?

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## Commercialization

The coatings being developed by C3 have been found to have additional excellent properties, including high hardness, carbon fouling resistance, low friction coefficient, and good corrosion resistance, so that the range of applications for these coatings has been greatly extended. Commercialization is under way in the areas of cutting tools, internal combustion engine components, bearings, and other applications.

## Benefits

- Scientific understanding of the C3 coating leads to increased acceptance of C3's coating for commercial use
- Improved "soldering" resistance for die used in aluminum die casting

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