LASER CVD FOR THERMAL BARRIER COATINGS DEVELOPED

In gas turbine technology ceramic coatings play a key role as far as thermal barrier coatings (TBCs) are concerned. Gas turbine blades are usually constructed using a nickel-based superalloy substrate, a bond coat layer that acts as an intermediate and ceramic thermal barrier coatings. Gas turbines operate at high temperatures and in order to improve the performance of gas turbines advanced TBCs are required. Recent advances in TBCs have enabled the operation of the gas turbine inlet at high-temperatures in the range of 1500 degrees C. Further improvement in the coating process and the TBC nanostructure would enable operation at higher temperatures.

The ceramic material used for TBCs must have properties like high mechanical properties, low thermal conductivity and thermal shock resistance. For this yttria stabilized zirconia (YSZ) has been widely used in practical applications. But, due to a slightly lower thermal coefficient of YSZ than nickel-based super alloy substrates, significant thermal stresses and cracks result in the TBCs that result in disastrous peeling off from the substrate.

Using various coating processes can help relax the thermal stress by controlling the microstructures of YSZ. Electron beam physical vapor deposition (EBPVD) and atmospheric plasma spray (APS) are the most commonly employed coating processes in practical applications. Chemical vapor deposition (CVD) is also another process that can be considered but thick coatings cannot be obtained fast using this processing technique. Laser CVD processes however have a high-deposition rate for YSZ and this has been the focus of study for Takashi Goto, a researcher at the Institute for Materials Research, Tohoku University, Japan.

"We have obtained very thick (more than several hundreds micrometers in thickness and several cm by cm substrates) oxide coatings, particularly yttria stabilized zirconia films, by laser assisted CVD. Many other oxides like aluminium oxide (Al_2O_3), yttrium oxide (Y_2O_3), titanium dioxide (TiO_2) and others were also fabricated at deposition rates of 0.7 mm/h to 3.0 mm/h," says Goto. The high deposition rates have resulted in a large number of nanopores in the grains that has lead to a smaller thermal conductivity of 0.7 W/mK.

This process appears to be very promising for TBCs as the researchers have already coated YSZ films on practical gas turbine blades. The researcher explains that TBCs are used not only for gas turbines but also missile, spacecraft, cutting tools and others. Other oxides are also promising for a number of applications, for example, Al_2O_3 for cutting tools, Y_2O_3 for anti-plasma etching coatings and TiO_2 for photo catalytic films.

What makes this work unique is that the wide-area substrates can be coated at very high deposition rates. It is also possible that using this technique very specific areas can be coated that would be useful for the repairing of TBCs. There seems to be no significant obstacles to the development of the laser CVD as the price of the laser is decreasing significantly and the equipment may become cheaper. The researcher says the price of

CVD precursors used to be rather expensive, but due to several technical developments, the price of metal organic (MO) precursors have been decreasing.

The research at this moment is supported by the government, which was performed as a part of a nano-coating project sponsored by the New Energy and Industrial Technology Development Organization, Japan. The researchers are also collaborating with companies mainly TBC related companies, cutting toolmakers and MO precursor makers. The next step in development with regard to this work could be the scale-up of the process by several times as this work has gone past the university level research stage. Additionally, the researcher has patented the laser CVD process.

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