Ceramics Manufacturing by Laser Chemical Vapor Deposition

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Chemical vapor deposition (CVD) is a versatile technique to synthesize films with finely controlled microstructure, and therefore it has been employed in industry for electrical and mechanical applications. CVD generally needs high-temperature to promote chemical reactions for deposition, and CVD is rather inefficient process to deposit materials. Laser-assisted chemical vapor deposition (LCVD) is known to deposit films at low temperature; however, it was only possible to prepare very thin and small deposits. We have found that high power continuous laser (semiconductor laser, Nd:YAG laser and CO_2 laser (~200 W) enables one to prepare films and bulky materials at significantly high deposition rates often more than several 1000 times higher than conventional CVD at moderate temperature. Since laser can heat only substrate surface area, premature chemical reactions in a gas phase often forming powder can be restrained. The deposition rate increases with increasing the supply of source gases, and reached 27.5 mm/h for SiO_2 film by using TEOS (Tetraethyl orthosilicate) and 5 mm/h for SiC film by using $SiCl_4$ and CH_4. Laser can also accelerate crystal growth of deposits on the substrate surface with insignificant nucleation in a gas phase, and thus highly (001)-oriented $YBa_2Cu_3O_{7-\delta}$ and (100)-oriented $NaTaO_3$ films have been prepared exhibiting the highest superconductivity and photocatalytic activity, respectively. Al_2O_3-ZrO_2, SiO_2-ZrO_2 and SiC-SiO_2 nano-composite films have been also prepared by LCVD by using multicomponent source gases. By scanning laser or moving substrate, large scale coatings such as YSZ (yttria stabilized zirconia) thermal barrier coating (several 100s μm in thickness) were fabricated on large scale and complicated shaped metal substrates (several centimeter in size).