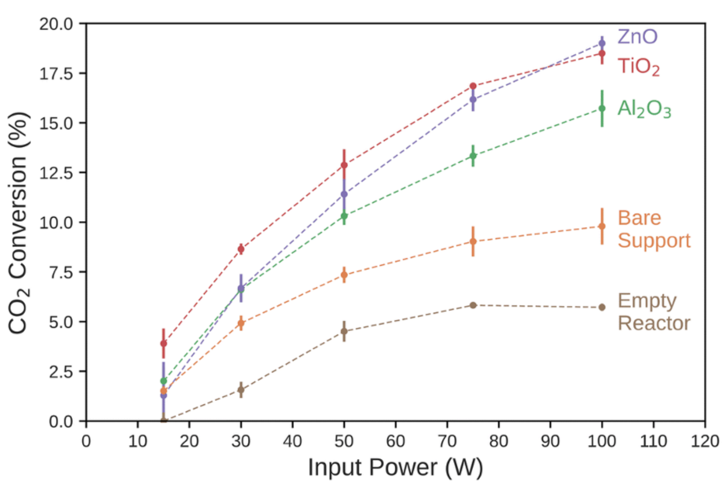
ARRADIANCE *Sneak Preview*

Efficient plasma transformation of captured CO_2 using ALD-enhanced catalysts

September 16, 2024

Many different technologies for capturing atmospheric CO_2 and transforming it into more useful molecules are under development, however an essential first step is the conversion of CO_2 into CO. Using low-temperature atmospheric pressure plasma to split CO_2 is one such example. Densely packed, high surface area catalysts reduce required CO_2 plasma processing temperature and increase power efficiency and CO production rate. Uniformly coating 3D structures with catalytic thin films is a complex task that is made significantly easier by Atomic Layer Deposition (ALD), uniquely suited for R&D work in this area.

The efficiency of particulate catalysts in plasma CO_2 conversion process depends not only on the material, but also on the particle size and how catalyst particles fill the reactor. Quite often, the packing of catalyst powders is heterogeneous, which complicates scientific comparison due to powder packing effects on gas flow through the reactor, plasma electric field distribution and discharge mode. This study[1] from the University of Arkansas and University of British Columbia, successfully separated catalyst support structure and packing effects from intrinsic catalyst chemical activity. They synthesized nanofilms of metal oxide catalysts on a much thicker aluminosilicate wool support, for use in a dielectric barrier discharge (DBD) plasma reactor. The reproducible packing structure of the wool dominates dielectric properties of the reactor (permittivity), isolating the catalytic effects of each material used in nanoscale ALD conformal coating.



TiO_2 is a well-known plasma CO_2 reduction catalyst around which to develop this technique. Al_2O_3 and ZnO are typical support materials for other catalysts in DBD plasma reactions. While both TiO_2 and Al_2O_3 behaved as expected, the authors observed a significant increase in the catalytic activity of ZnO by increasing reactor power. The discovery of a significant catalytic behavior from a material (ZnO) that is conventionally a support material, is new. More generally, this work shows that ALD can be used to isolate catalytic activity from other effects (mass transport, plasma variability near dielectric interfaces) in complex plasma reduction reactions. The ALD layers were grown in an Arradiance GEMstar XT™ ALD reactor. The Arradiance reactor is excellent for coating high surface area structures uniformly, in both flow through and expo modes of deposition, and support sequential infiltration synthesis (SIS).

Arradiance enables thin-film semiconductors, solar and green energy state-of-the-art ALD solutions. For more information on GEMStar™ Technology, ALD systems or Foundry services, please contact Arradiance.

1. Samuel K. Conlin, Hamed Mehrabi, David N. Parette, Eva M. Nichols, and Robert H. Coridan, "Characterizing catalyst function and transformations in the plasma reduction of CO_2 on atomic layer deposition-synthesized catalysts", RSC Appl. Interfaces, 2024, 1, 552. DOI: 10.1039/D3LF00271C