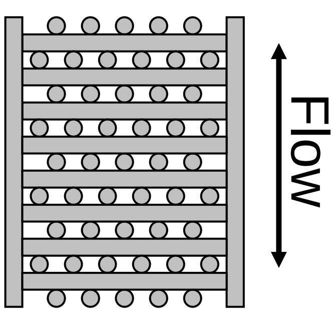
**ROBOCASTING ENTERPRISES LLC**

**Research Brief - November 2007**

# Advanced Catalyst Support Structures

***Motivation:** Monolithic catalytic reactors, widely utilized for environmental applications (automotive and stationary emissions control), are currently being considered for a variety of additional applications. Monoliths offer several advantages over traditional packed bed systems; perhaps the most significant of these is offering a high surface/volume ratio (similar to that of very small particles) with little resistance to flow (low pressure drop). Many of the potential new applications require very high gas flow rates (with space velocities up to $10^6$ $hr^{-1}$). However, an inherent weakness of most monoliths is the potential for bulk gas-solid mass transfer limitations under high flow conditions. An additional limitation is that most monoliths are not applicable to highly endothermic or exothermic reactions where radial heat transfer is critical.

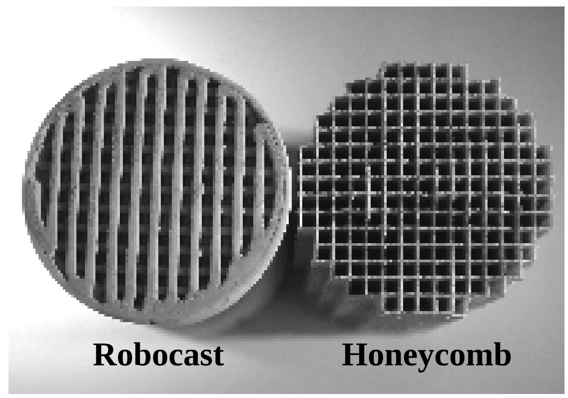
Robocasting can produce 3-dimensional ceramic monoliths, e.g. meshes with controlled porosity in all dimensions but no line-of-sight pathways. Compared to the traditional 2-dimensional "honeycomb" structured extrudates, our 3-dimensional structures promote higher mass transfer rates to catalytic surfaces while maintaining high surface to volume ratios, predictable permeability, and low pressure drop. Robocasting allows for great flexibility in materials, possibly alleviating problems related to thermal shock and chemical degradation.



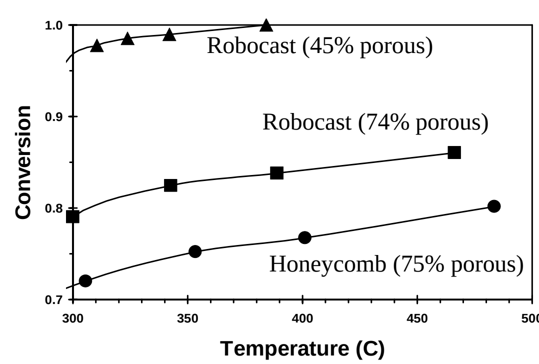

Schematic of a cross section of an 'FCC-like' geometry of alternating rods

* Original research was performed with J. Miller and R. Ferrizz at Sandia National Laboratories

**Accomplishments:** Using CO oxidation over Pt as a probe reaction, it has been shown that Robocast monoliths with an "FCC-like" geometry of alternating rods (for which there are no direct line-of-sight pathways) exhibit superior mass transfer properties relative to traditional honeycomb monoliths.




Robocast and honeycomb samples with identical dimensions, geometric surface areas, and catalyst loadings were both subjected to a high flow rate of 13,000 sccm (~750,000 $hr^{-1}$) of 1% CO in air. At 350 °C, it is evident from conversion vs. temperature plots that both samples are clearly in the mass-transfer-limited kinetic regime. CO conversion over the Robocast sample was 99%, while it was only 75% over the honeycomb sample. This corresponds roughly to a 3-fold increase in the Sherwood Number (a measure of convective mass transfer).

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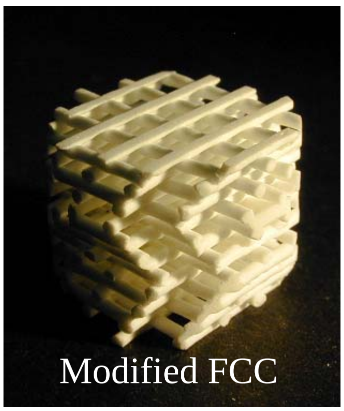
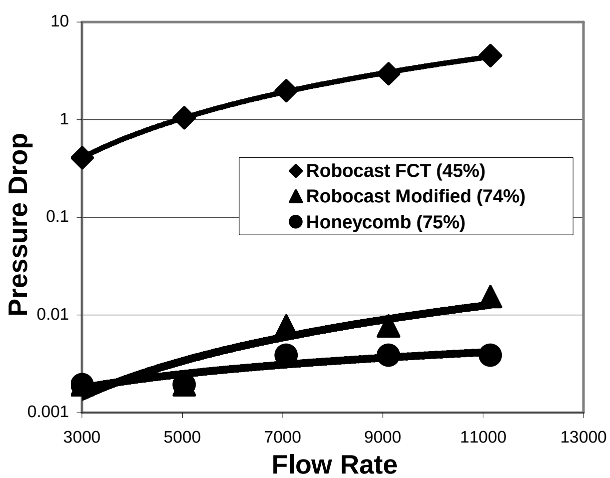
The reported gain in mass transfer was made at the expense of a significant increase in pressure drop. However much of this increase is due to the relatively small bulk porosity of the FCC sample (45%). A Robocast sample that more closely matches the bulk porosity (74%), pressure drop, and surface area of the honeycomb monolith was tested and is also shown. This sample exhibits enhanced mass transfer properties (88% conversion at 350 °C) and no line-of-sight pathways.




**Significance:** The superior properties exhibited by Robocast monoliths could potentially reduce the amount of precious metals needed for reactions by way of enhanced mass transfer. The flexibility of the Robocasting process allows for the creating of supports with tailored structure and thus, tailored flow properties.

**Related Research Briefs:**

- Robocast monolith structures have been proven to have higher flow reproducibility than reticulated foam monoliths. *See Research Brief: Consistent Flow through FCT Structures.*
- If economically feasible, the monolith can be fabricated from the catalyst material itself instead of washcoating. Significant gains in catalytic activity result. *See Research Brief: Robocast Catalyst Monoliths Show Enhanced Conversion.*
- Thermal runaways and thus a chance for catalyst sintering and performance loss may be reduced with Robocast monolithic supports. *See Research Brief: Novel Diesel Particulate Traps from Robocasting.*

**Robocasting Enterprises is the sole licensee for manufacturing with this technology**

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