Recent Progress in the Development of Perfectly Ordered Separation Media

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The present contribution aims at illustrating and demonstrating how micro-machining technology can boost High Performance Liquid Chromatography (HPLC). Currently, HPLC is routinely used in nearly every chemical analysis lab. Despite its high degree of maturity, the technique still does not deliver the required separation power needed to unravel the complex samples encountered in the state-of-the-art research in biology and drug development (e.g., proteomics and metabolomics), or in contemporary food and environmental analysis, etc…..

One of the reasons for the performance limitations of packed bed HPLC columns is that they are packed randomly. This randomness forces the liquid to follow different paths with different path lengths, which in turn broadens the individual sample component bands. To solve this packing disorder problem, we have used advanced photolithographic etching techniques such as the Bosch-process to produce perfectly ordered porous support columns with optimized hydrodynamic shape and optimized external porosity. Using this approach, we have been able to realize sub-micrometer plate heights using radially elongated diamond-shaped pillars that are up to 15 times wider than their axial dimension (5 µm). The use of such a high-aspect ratio pillars allowed for a 5-fold reduction of the minimal plate height compared to beds filled with pillars with a similar inter-pillar distance (2.5 µm) but with an aspect ratio around unity (cylinders, diamonds). This increase in performance can be largely attributed to a decrease of the B-term band broadening, which is about a factor of about 25 smaller in the large-aspect ratio columns compared to the cylindrical pillar columns. In addition, the columns also generate only a minimal C-term band broadening, as the space formed between the high-aspect ratio pillars is very uniform and basically resembles the through-pore space one would have in a parallel array of flat plates. The concept also enables a drastic reduction of the footprint of pillar array columns, allowing to fabricate columns offering very high efficiency on the surface of a single silicon wafer.