Microreactors for Synthesis of Quantum Dots
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We have fabricated a gas-liquid segmented flow reactor with multiple temperature zones for the synthesis of quantum dots (QDs). In contrast to single-phase flow reactors, the segmented flow approach enables rapid mixing and narrow residence-time distributions, factors which have a strong influence on the ultimate QD size distribution. The silicon-glass reactor accommodates a 1-m long reaction channel (hydraulic diameter ~400-µm) and two shallow side channels for collecting reaction aliquots (Figure 1). Two temperature zones are maintained, a heated reaction region (>260°C) and a cooled quenching region (<70°C). As a model system, monodisperse CdSe QDs with excellent optical properties were prepared using the reactor. Cadmium and selenium precursor solutions are delivered separately into the heated section. An inert gas stream is introduced further downstream to form a segmented gas-liquid flow, thereby rapidly mixing the precursors and initiating the reaction. The reaction is stopped when the fluids enter the cooled outlet region of the device. Under conditions for a typical synthesis, the gas and liquid segments are very uniform (Figure 2a-b), and the QDs produced in the reactor possess narrow spectral features, indicative of monodisperse samples. The narrow particle size distributions arise directly from the enhanced mixing and narrow residence-time distribution realized by the segmented flow approach. Furthermore, the QD size can be tuned without sacrificing monodispersity by varying the Cd and Se precursor flow rates. In Figure 2d, the Se/Cd molar ratio was varied while keeping the total liquid and gas flow rates constant. Decreasing Se/Cd results in a substantial red shift of the QD effective band-gap (first absorption feature and photoluminescence peak), corresponding to larger QD diameters.

REFERENCES