SELF-ROLLED UP TUBULAR OPTICAL MICROCAVITIES

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This work reports one interesting optical microcavity: self-rolled up optical microcavity with tubular geometry. Several different fabrication processes for the microtubular optical cavities had been reported [1]. Different from transitional fiber-drawing technique [2], the nanomembrane with pre-defined geometries can be bend into a curved structure and forms a three dimensional (3D) tubular structure by predefined strain-engineering via lift-off technology [3, 4]. Our group focus on the research on the optical properties of these self-rolled up optical microcavities [5, 6].

A schematic view of the self-rolled up processes is illustrated in Figure 1 [1]. The nanomembranes released via the lift-off processes from the sacrificial layer on substrate. Then, the freestanding nanomembranes self-rolled up into microtubes and performed as optical microcavities. The typical micro-photoluminescence (μ-PL) spectra of these rolled-up microtubes in various color regions are shown in Figure 2 [5]. Various interesting materials (Figure 2) were used for the fabrication of self-rolled up tubular optical microcavities in difference spectral range [5]. As shown in Figure 3, the μ-PL spectra measured at different positions along the micro-tubes by rolling circular nanomembranes indicates an evident 3D optical confinement. The WGMs shift to lower wavelengths when moving from the middle to the end of the micro-tubular cavity along the z direction. We consider that this interesting phenomenon in WGMs (both emergence of sub-peaks and the shift of modes) should be intimately connected with the geometrical structure of the micro-tubular cavity. Effective surface modification and geometry design will introduce special optical properties in these self-rolled up microcavities [6].

The rolling process has been provides a convenient way to produce a stack of multilayers made from different materials with tunable geometry, demonstrating a new method to prepare optical microdevices. The future of rolled-up microcavities lies in many aspects from fundamental science to practical applications. The corresponding resonance can thus be tuned in terms of wavelength range and Q-factor. Functional materials may also be incorporated to achieve effective coupling between the light and other physical fields, giving birth to special micro devices with good tunability. Meanwhile, rolled-up thin-walled oxide tubular microcavity delivers a new optical component for light coupling and may imply interesting applications in the interaction between light and matter [6]. Considering the on-chip integratability of rolled-up structures, researchers may also be able to produce a sensing device to realize lab-in-a-tube [3].

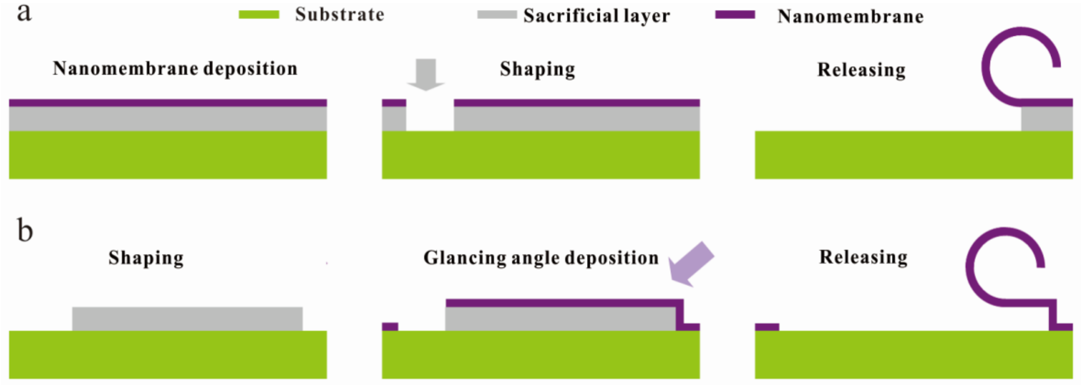

Fig.1 Schematic diagram of the formation of selfrolled-up microtube: (a) inorganic self-rolledup procedure; (b) organic-based self-rolled-up procedure [1].

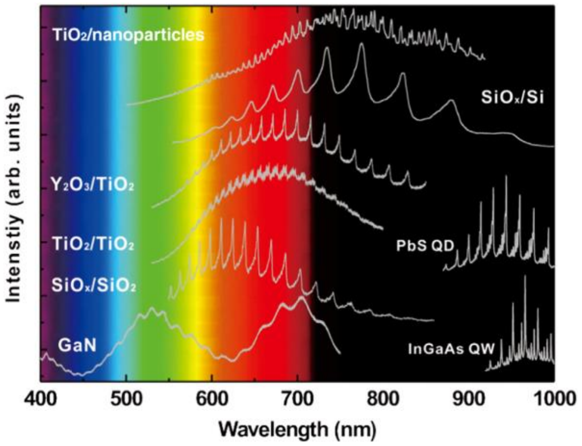

Fig. 2 The micro-photoluminescence (μ-PL) spectra of rolled-up microtubes in various color regions, which are composed of SiO_x/Si (Q ~ 100), SiO_x/SiO_2 (Q ~ 100), Y_2O_3/ZrO_2 (Q ~ 1500), TiO_2 (Q ~ 1500), InGaAs QW(Q > 2000), PbS QD (Q > 1000), TiO_2/nanoparticles (Q > 1200) and GaN (Q ~ 100) [5].

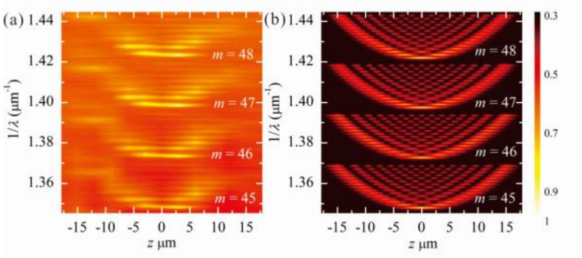

Fig. 3 (a) Color-coded PL intensity (experimental) as a function of the emission wavelength and the distance from the middle of the Y_2O_3/ZrO_2 micro-tubular cavity. (b) Simulation result of the PL intensity distribution along the z axis [7].

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