**Lanthanide-doped upconversion microcrystals with luminescent**

**properties of**

**multicolor tuning and**

**dual-mode emission for** **anti-counterfeiting**

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### Abstract (300 word limit)

Lanthanide-doped upconversion(UC) materials always attract wide attention due to their special anti-Stokes shifting, which allow emitting visible light under near-infrared (NIR) light excitation. The UC materials can be applied in many fields, including biomarkers, display, security printing, solar cells, photodynamics therapy (PDT), and temperature sensing. Among all the UC hosts, NaLnF4 (Ln=Y3+, Lu3+, Gd3+) hosts are considered as suitable materials for UC emission. However, the utilization of traditional UC materials is limited by their low luminescence efficiency and intractable emission color.

Distorting the symmetry of the crystal environment surrounding Ln3+ is an effective method of increasing UC luminescence intensity, and doping is a potential route to tailor the environment around Ln3+ ions. Simply tuning the co-doping concentration of ions with different valences (Li+ and Lu3+) could not only modify the morphology and size of NaYF4:Er/Yb microcrystals but also enhance the emission intensity without changing the phase of the host matrix, and meanwhile, both the excitation power density and pump wavelength are responsible for color-tuning properties of the bulk microcrystals which suffer from the insensitive response to excitation power before. The changing colors can be easily distinguished with naked eyes and multicolor emission of NaYF4:Er/Yb/Li/Lu would create an exciting possibility for easily visualizing anti-counterfeit pattern instead of complicated decoding setup.

Besides, we synthesized the uniform core-shell structured NaLnF4@-NaLnF4 microcrystals via the epitaxial growth technique. These microscale core-shell structures provided a platform for the spatially confining optical process while possessing high luminescence efficiency. The uniform NaYF4@NaLnF4 microrods, with a series of rare-earth ions doped into the core and shell layer at various doping concentrations, achieved color-tuning of the upconversion emission and dual-mode emission at the single-microcrystal level, making them ideal candidates in photovoltaic and anti-counterfeiting applications.

**Recent Publications ()**

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### 2. D. Ju, F. Song, Y. Han, W. Cui, A. Zhou, S. Liu, X. Wang, M. Feng, C. Ming, Nanomaterials, 2017, 7(12): 448.

### 3. D. Ju, F. Song, J. Zhang, C. Ming, F. Song, A. Khan, A. Zhou, L. Liu and X. Wang, CrystEngComm., in peer review.

### 4. N. Yuan1, H. Sun1, D. Ju, D. Liu, Z. Zhang, W. Wong, F. Song, D. Yu, E. Y.B. Pun and D. Zhang, Materials Science and Engineering: C, 2017, 81: 177-181.

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Biography (150 word limit)

Dandan Ju is a doctoral candidate of the Key Laboratory of Weak Light Nonlinear Photonics at Nankai University, China. Her research interest includes the synthesis, design and application of lanthanide-doped upconversion microcrystal, focusing on increasing the upconversion luminescence efficiency and achieving multicolor emission for practical application, such as photovoltaic, security purpose, etc.

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### 2. Y. Zhang, L. Huang, X. Liu, Angewandte Chemie International Edition,2016, 55:1-6.

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