Electronic Supplementary Material (ESI) for Nanoscale.
This journal is © The Royal Society of Chemistry 2021

- Electronic Supplementary Information (ESI) -

TiN deposited onto the D-shaped fiber as an optical modulator for ultrafast photonics and temperature sensing

*Fang Wang[a], Dongfang Lan[a], Xuenan Zhang[a], Tonglei Cheng[a,b]**

[a]*State Key Laboratory of Synthetical Automation for Process Industries, the College of Information Science and Engineering, Northeastern University, Shenyang, 110819, China*

[b] *Hebei Key Laboratory of Micro-Nano Precision Optical Sensing and Measurement Technology, Qinhuangdao, 066004, China.*

Corresponding Author

Tonglei Cheng, e-mail: chengtonglei@ise.neu.edu.cn

Supplementary Materials and Methods

1. The preparation of TiN NPs

All of the approaches were carried out in a dry glovebox with N_2 flowing. In a typical procedure, 2.4 mL of $TiCl_4$, 1.07g of NH_4Cl, and 2.30 g of metal Na particles were put into an autoclave of 50 mL capacity. The autoclave was sealed and maintained at 500°C for 6 h and then cooled to room temperature naturally. The product was dispersed and washed with absolute alcohol, 0.5 mol/L HCl, and distilled water, respectively. A red-brown product was collected and dried under vacuum at 60 °C for 4 h.

2. Calculation of the evanescent field intensity

The field strength of fiber evanescent field can be expressed as follows:

$$E = E_0 exp(-z/d_p) \quad \text{(S1)}$$

Where, E_0 is the energy intensity of evanescent field at the interface, z is the distance from the field point to the interface, and d_p is the penetration depth of evanescent field. d_p is defined as the distance between the field point and the interface when the intensity of the energy field drops to $(1/e)E_0$. The equation is expressed as follows:

$$d_p = \lambda / \left(2\pi\sqrt{n_1^2 sin^2\theta - n_2^2}\right) \quad \text{(S2)}$$

Where, λ is the wavelength of light when it propagates in a vacuum, n_1 is the refractive index of the optical fiber core, n_2 is the refractive index of the fiber cladding, and θ is the incident angle of light at the interface. It can be seen that the intensity of evanescent field of the same DF is positively correlated with the wavelength. By substituting the relevant parameters of DF (SMF-28e) into Equations (S1) and (S2), we can get the relationship between the intensity of evanescent field on the external surface of SPF and the wavelength.

3. Saturable absorption property model for the measured data

The following equation was used to fit the measured data.

$$\alpha(I)=\frac{\alpha_S}{1+I/I_S}+\alpha_{NS} \qquad \text{(S3)}$$

where the parameters (a_s, a_{NS} and Is) are the modulation depth, nonsaturable loss, and saturation power density, respectively.

Supplementary Figures

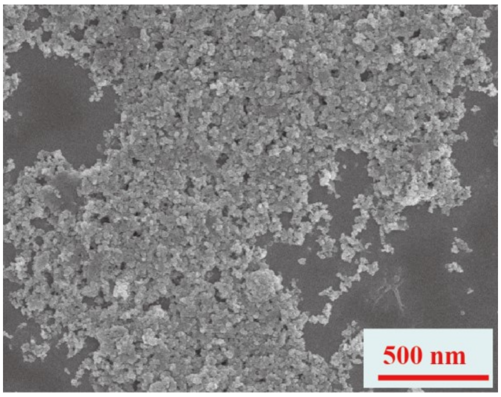

Fig. S1 SEM image of the as-synthesized TiN nanoparticles.

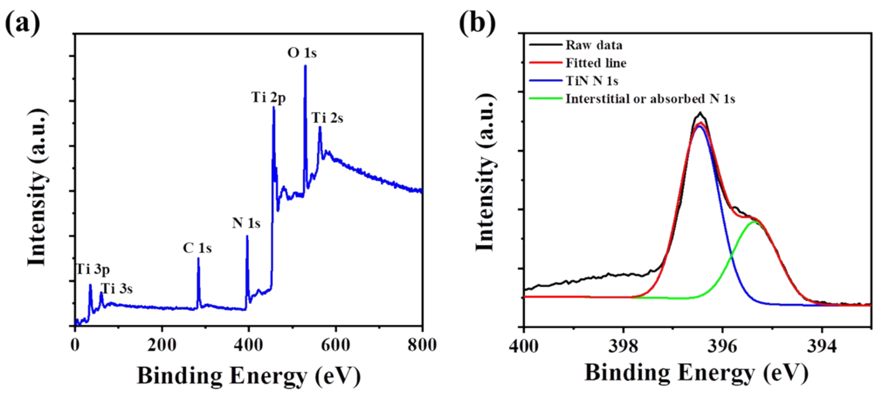

Fig. S2 XPS spectra of the TiN nanoparticles.

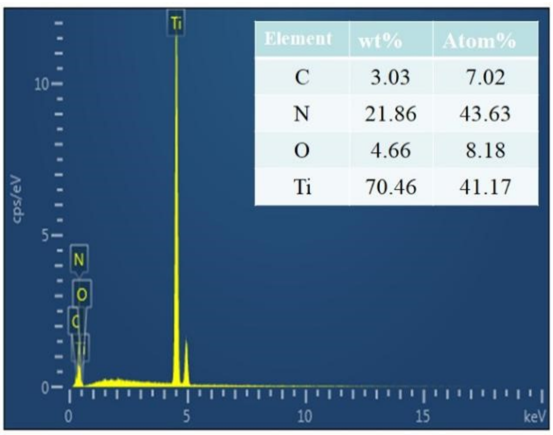

Fig. S3 EDS spectra of the TiN nanoparticles. Inset of the Figure shows the atom ratio of synthesized sample

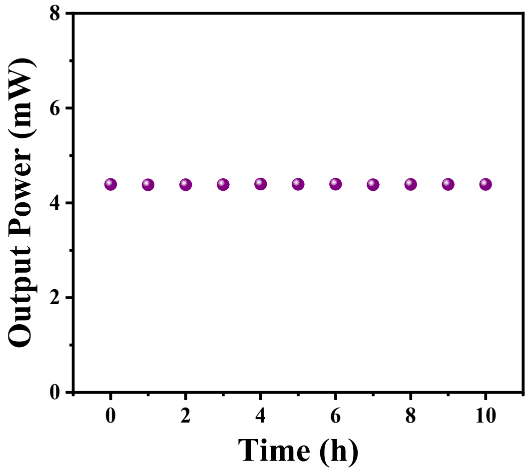

Fig. S4 Output power of the mode-locked lasers at 1.53 μm for the pump power of 236 mW at 1 h interval.

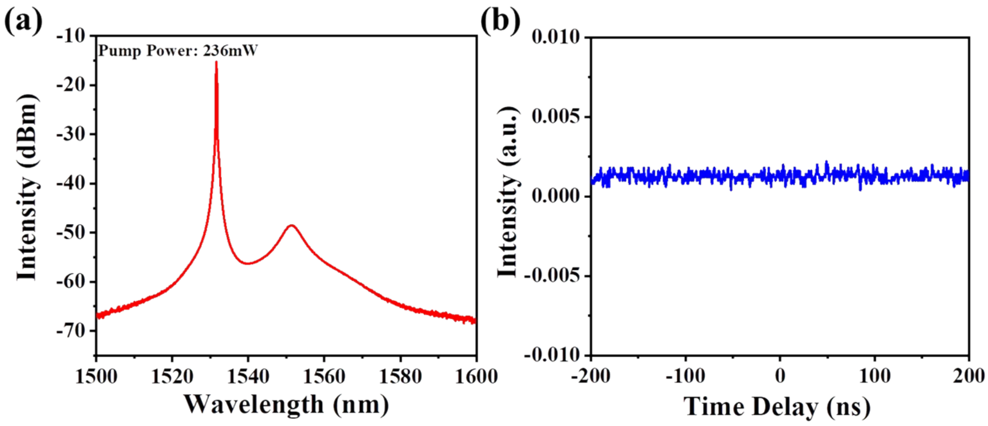

Fig. S5 (a) Emission spectrum of the EDFL with a bare DF, and (b) laser intensity as a function of time for a pump power of 236 mW.

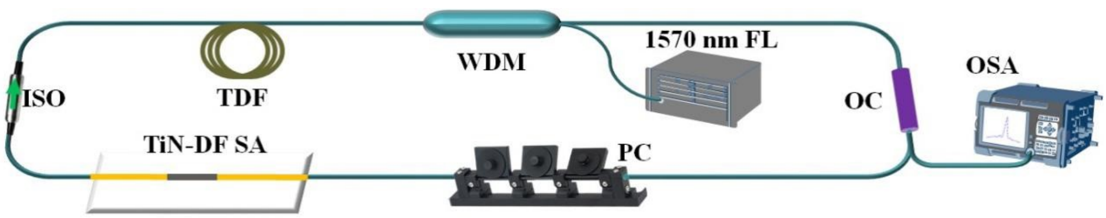

Fig. S6 Experimental setup of the thulium-doped fiber laser ring cavity.

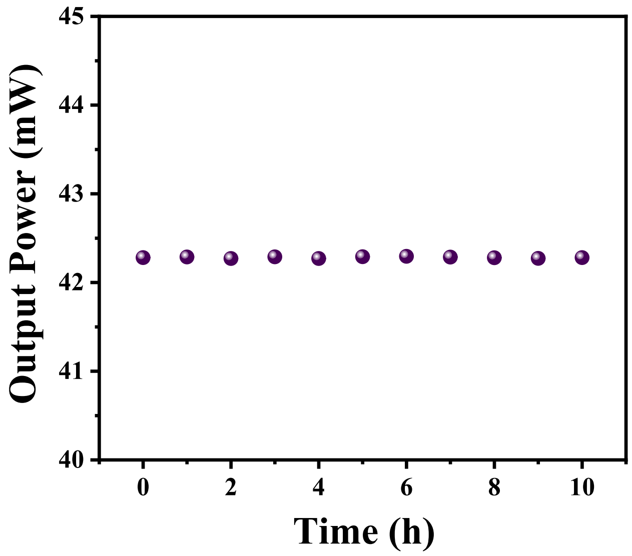

Fig. S7 Output power of the mode-locked lasers at 2 μm for the pump power of 2.1 W at 1 h interval.

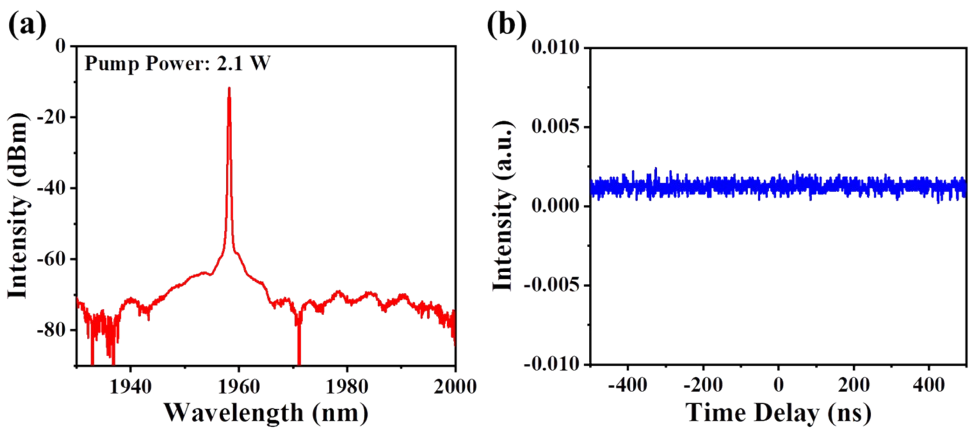

Fig. S8 (a) Emission spectrum of the TDFL with a bare DF, and (b) laser intensity as a function of time for a pump power of 2.1 W.