Supporting Information for

The Aerogel for Random Lasing and Sensor with Thermal Insulation

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Figure S1. A set of aerogels was prepared using custom molds, demonstrating the scalability of the preparation process.

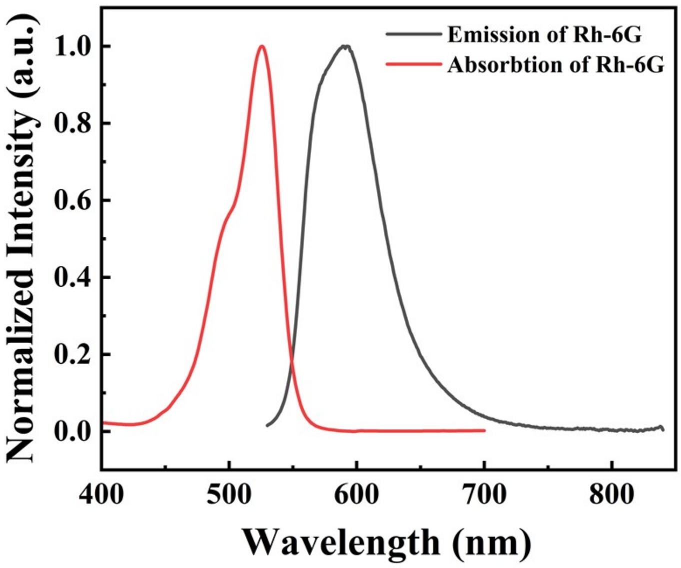

Figure S2. Absorption and emission spectrum of dye Rh-6G.

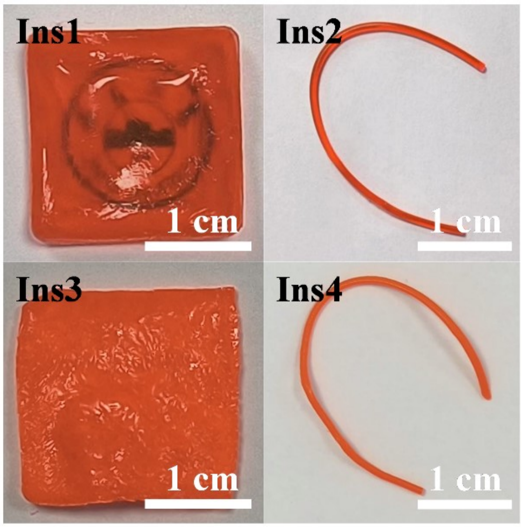

Figure S3. Images of the d/AP-3H film (Ins1) and fiber (Ins2), and the d/AP-3A film (Ins3) and fiber (Ins4).

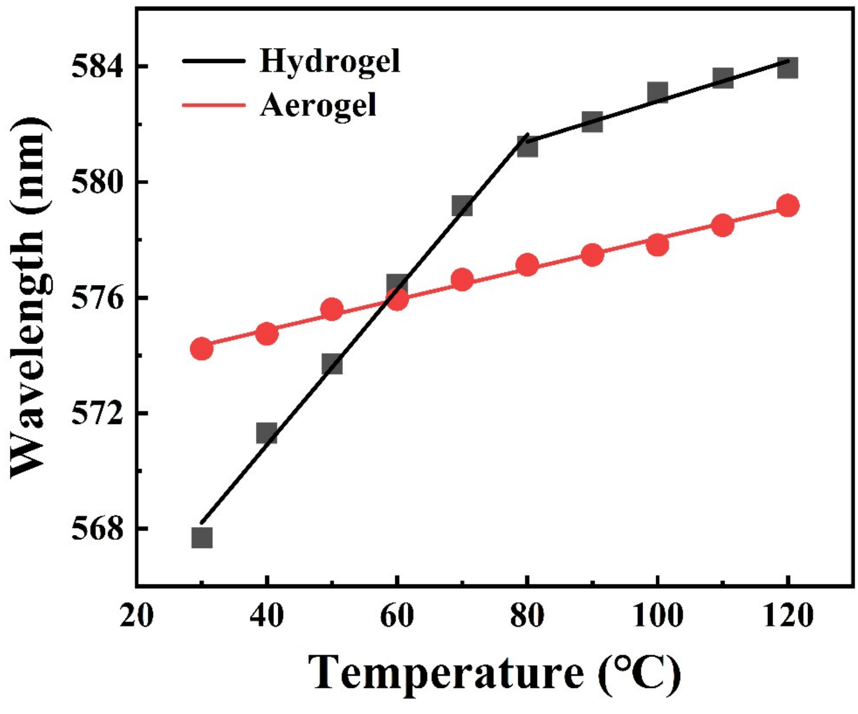

Figure S4. The RL peak wavelength shift of d/AP-3H film and d/AP-3A film with increasing temperature. The redshift rate is faster from 30 ℃ to 80 ℃, but beyond 80 ℃, especially after 90 ℃, the RL peak wavelength redshift rate of d/AP-3H film significantly decreases. The RL peak wavelength redshift rate of d/AP-3A film is much lower than that of hydrogel.

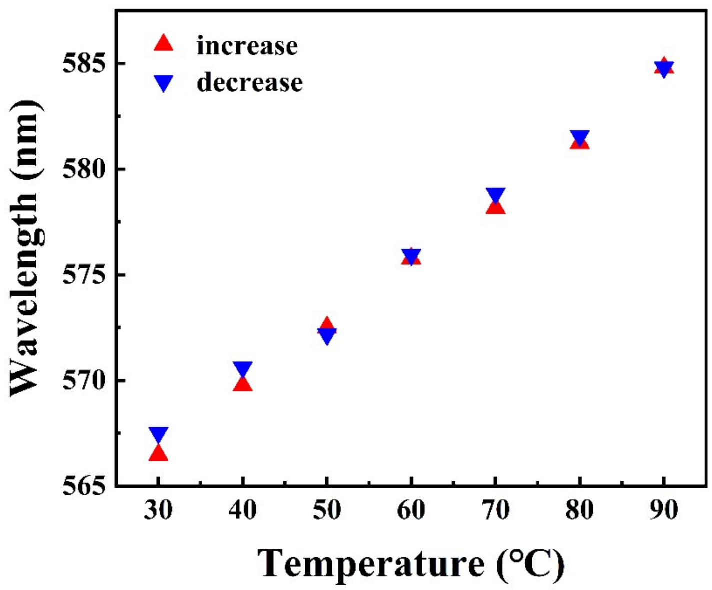

Figure S5. The random laser emission wavelength of d/AP-3H fibers undergoes a redshift with increasing temperature within the range of 30-90 °C, and this redshift exhibits a linear relationship with temperature. Furthermore, this redshift is reversible.

Table S1. Comparison of thermal conductivity of aerogels in this work with different insulation materials in the literature.

Insulation materials	Thermal conductivity (mW $(mK)^{-1}$)	Reference
Nanowood	30	[1]
Pectin	33	[2]
Cellulose fibers	33	[3]
Polyamide	39	[4]
Lignin	40	[5]
Carbon fiber	81	[6]
This work	**28**	

In this work, the Fiber Bragg Grating (FBG) is introduced as a temperature sensing element to further verify the thermal insulation performance of the aerogel. According to the theory of optical coupling, after the light passes through the grating, the center reflection wavelength of the FBG, λ_B, can be defined by the relationship:[7]

$$\lambda_B = 2n_{eff}\Lambda \quad \textbf{(1)}$$

where n_{eff} is the effective refractive index of the fundamental mode of the fiber core, and Λ is the grating period.

The change in wavelength at the center of the fiber grating due to temperature change can be expressed by the following relationship:[8]

$$\frac{\Delta\lambda_B}{\lambda_B} = (\xi + \alpha)\Delta T \qquad \textbf{(2)}$$

where, ΔT is the change in temperature, α is the thermal expansion coefficient of the fiber core and ξ is the thermal-optic coefficient of the fiber material.

Notes and references

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