# Rhodamine-doped aerogel random laser

**Adriana Ramos de Miranda*, Édison Pecoraro**, Sidney José Lima Ribeiro**, Júlia Maria Giehl*, Saara-Maarit Reijn*, Niklaus Ursus Wetter***
**** Centro de Lasers e Aplicações, CNEN-IPEN/SP, Av. Prof. Lineu Prestes, 2242***
***Cidade Universitária - CEP 05508-000 São Paulo – SP - Brasil***
***** Universidade Estadual Paulista Júlio de Mesquita Filho - Instituto de Química de Araraquara***
*Rua Prof. Francisco Degni, 55 - Jardim Quitandinha – CEP 14800-900 - Araraquara – SP - Brasil*
*a.r.miranda@terra.com.br*

**Abstract:** Random Laser generation can give valuable information on the structure of diffuse materials. The aerogel matrix has knowingly a fractal organization. Here, random laser generation from an aerogel matrix doped with rhodamine 6G was established.

## 1. Introduction

The study of the optical signal emitted by random lasers (RL) can provide accurate information about the structure of the scattering material [1, 2]. Therefore, disordered materials that can be produced by controlling the characteristics of the micro-structure itself are of great interest for the development and comprehension of the phenomenon [3]. In this context the laser generation from aerogel matrix doped with rhodamine 6G could be a promising methodology.

Silica aerogel is a material well known for its good mechanical and thermal properties. However, its optical properties have received much less attention [4], because it is optically not transparent. For the same reason, low-density silica aerogel (LDSA) can be used as host for random lasers systems. To the best of our knowledge, it is the first time that monoliths of LDSA are used as scattering matrix for rhodamine 6G based random laser. The temporal and spectral characteristics are being studied as well as specific characteristics of scattering in aerogel matrix.

## 2. Methods

### 2.1. Rhodamine 6G Silica Aerogels synthesis

The reagents tetraethyl orthosilicate (TEOS), ethyl alcohol, hydrochloric acid, ammonium hydroxide solution (28.0-30.0% $NH_3$ basis) and Rhodamine 6G hydrochloride were used. The two-step catalyzed TEOS based doped xerogels (hydrolysis and gelation) were prepared from TEOS, ethanol, HCl and $NH_4OH$. After remove any residual solvent through of a homemade $CO_2$ critical point drier, the samples were heat treated.

### 2.2. Experimental setup

Coherent emission from the RL is an interference phenomenon which occurs preferably in the backscattering direction [5]. In this way, the backscattered luminescence of the studied sample is separated from the pump beam through a dielectric beam splitter and then captured for the spectral and temporal analysis. Optical pumping was initially performed with a frequency doubled Q-switched Nd:YAG laser. Pulses with maximum pulse energy of 3 mJ (at 532 nm) were generated with duration of 10 ns at a repetition rate of up to 5 Hz. Currently, all data have been reproduced using an Optical Parametric Oscillator (OPO) with pulses of 9 ns and 10 Hz. Temporal and spectral profiles of the random laser emission are taken and the energy of the pump pulse is measured simultaneously, while the laser is operated in “single shot” mode.

## 3. Results and discussion

In a first experiment, the luminescence profile of the rhodamine-doped aerogel was measured. The rhodamine luminescence peak in silica matrix occurs between 555 nm and 565 nm, which is shorter when compared to the luminescence peak in ethylene glycol. Figure 1 shows laser emission in 555 nm of the rhodamine-doped aerogel sample during pumping with 532 nm.

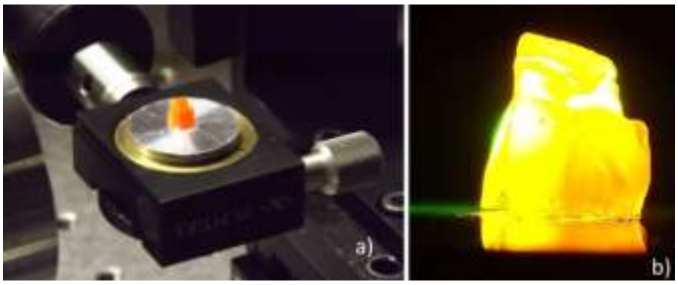


Fig. 1: (a) Rhodamine-doped aerogel sample in setup, (b) laser emission of the sample in 555 nm.

Increasing of the pump pulse energy generated a narrowing of the temporal and spectral profile of the RL emission in the backscattered direction, together with increased amplitude and higher RL pulse energy. The input-output curves (Fig. 2) clearly show two operation regimes, suggesting an onset of laser oscillation.

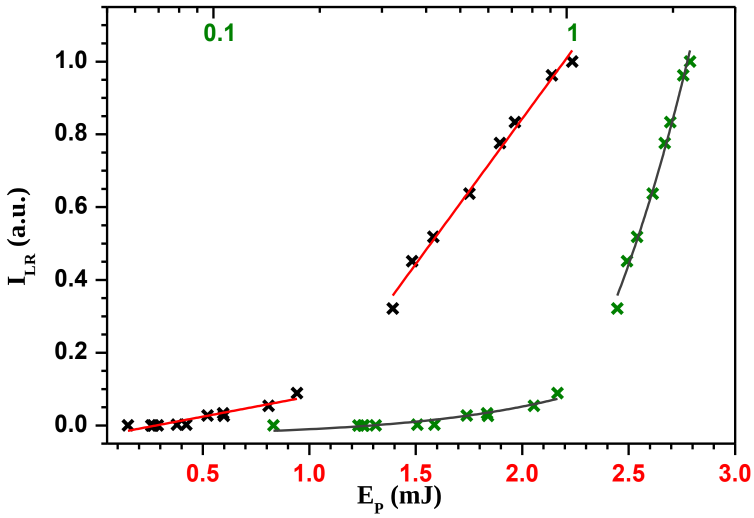


Fig. 2: Integrated output intensity ($I_{LR}$) as a function of pump energy ($E_P$) – linear scale (black) and logarithm scale (green).

## 4. Conclusion

We demonstrate for the first time random laser action from rhodamine-doped aerogel. By increasing the pump pulse energy we achieve spectral and temporal narrowing and increase of the emission energy of the random laser. Studies on the scattering dynamic of the aerogel are being conducted. Soon, more details of the random laser generation will be publishing.

## 5. Acknowledgments

The authors acknowledge the financial support provided by CNPq and FAPESP.

## 6. References

[1] R.C. Polson, Z.V. Vanderny, "Random lasing in human tissues", Appl. Phys. Lett. **85,** 1289-1291 (2004).

[2] Q. Song, S. Xiao, Z. Xu, J. Liu, X. Sun, V. Drachev, V.M. Shalaev, O. Akkus, Y.L. Kim, "Random lasing in bone tissue", Opt. Lett. **35,** 1425-1427 (2010).

[3] P. D. García,1, R. Sapienza, C. Toninelli, C. López, and D. S. Wiersma, "Photonic crystals with controlled disorder", Phys. Rev. A **84**, 023813-1–7 (2011).

[4] W.J. Platzer, M. Bergkvist, "Bulk and surface light scattering from transparent silica aerogel", Sol. Energ. Mat. Sol. C. **31,** 243-251 (1993).

[5] X. Wu, W. Fang, A. Yamilov, A. A. Chabanov, A. A. Asatryan, L. C. Botten, H. Cao, "Random lasing in weakly scattering systems", Phys. Rev. A **74**, 053812-1–11 (2006).