

# Lasers for Lithotripsy

Petr Koranda<sup>a\*</sup>, Helena Jelínková<sup>a</sup>, Michal Němec<sup>a</sup>,  
 Jan Pokorný<sup>b</sup>, Oto Köhler<sup>b</sup>, Pavel Drlík<sup>b</sup>  
 Mitsunobu Miyagi<sup>c</sup>, Katsumasa Iwai<sup>c</sup>, Yi-Wei Shi<sup>d</sup>, Yuji Matsuura<sup>e</sup>

<sup>a</sup>Czech Technical University, Fac. of Nucl. Sci. and Phys. Eng., Czech Republic

<sup>b</sup>Central Military Hospital, Clinic of Urology, Czech Republic

<sup>c</sup>Sendai National College of Technology Japan

<sup>d</sup>Fudan University School of Information Science and Engineering China

<sup>e</sup>Tohoku University Department of Electrical Communications Japan

## Abstract

Laser-assisted lithotripsy is a minimally-invasive method for destroying or disruption of human urinary stones. For this purpose laser light delivered through the flexible sealed waveguide or fibre could be utilized. On the output end of the delivery system the laser light is focused onto the surface of urinary stones with various size and various composition. In clinical urological practise the Ho:YAG laser with the generated wavelength 2100 nm operated in free-running regime is commonly used.

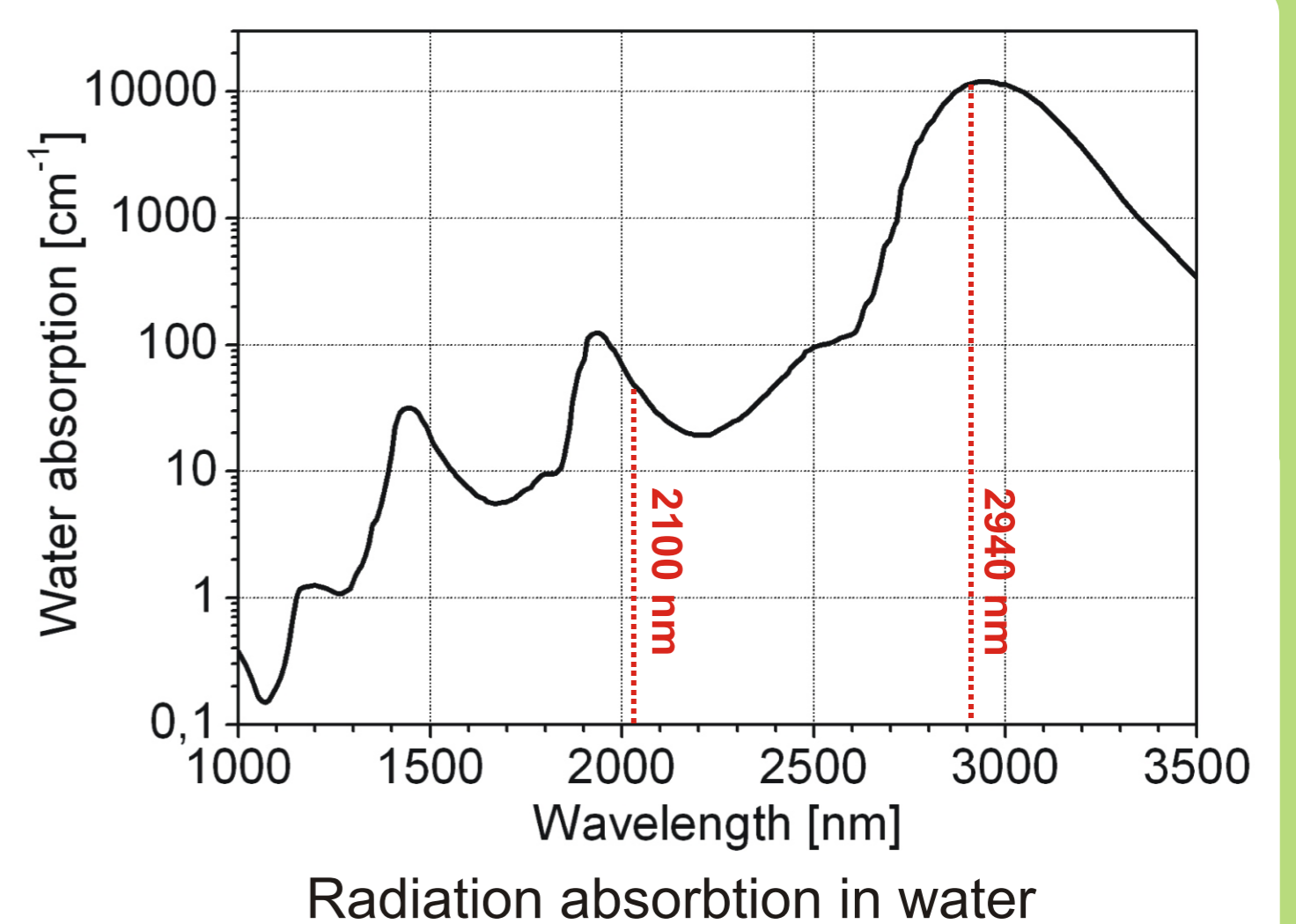
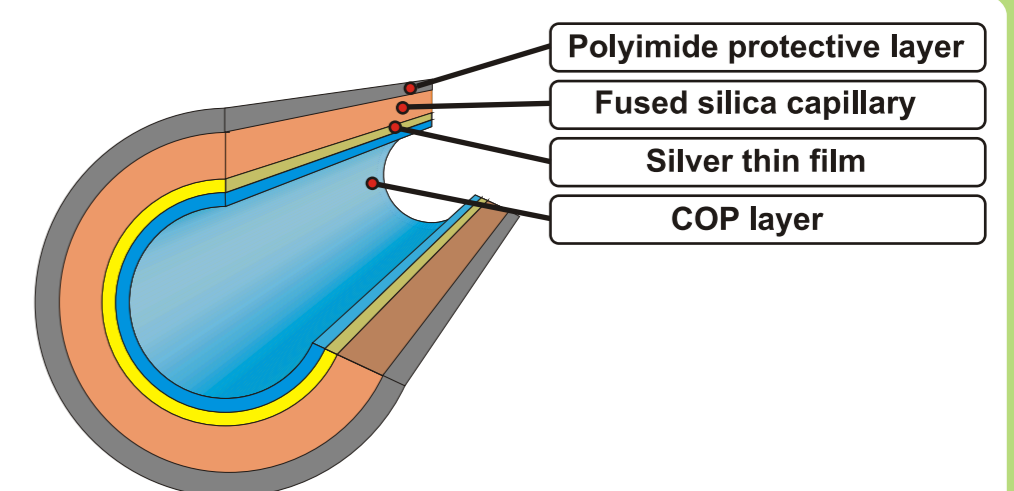
The aim of our investigation was to compare the ablation and disruption effects of Ho:YAG laser radiation with the promising Er:YAG laser radiation. The Er:YAG laser generates radiation with the wavelength 2940 nm, which coincides with the local absorption maximum of water. We have compared the laser effect with the help of uniformly produced model samples made from special plaster. The size of the samples was up to 10x10x10 mm.

The perforation and disruption effectiveness of Ho:YAG and Er:YAG laser radiations were performed and compared. In the final step the laser lithotripsy of human urinary stones was tested with Er:YAG laser radiation delivered through the special COP/Ag hollow waveguides sealed with fused silica cap.

## COP/Ag Hollow Waveguides

Cyclic Olefin Polymer-coated silver hollow glass waveguide

- Inner diameter 700  $\mu\text{m}$
- Outer diameter 850  $\mu\text{m}$
- Length 100 mm
- Terminated by the fused silica cap
- Transmission 70 - 80% in MIR
- Flexible delivery system



## Compared Lasers

### Ho:YAG

Flashlamp-pumped  
 Wavelength 2100 nm  
 Repetition rate 1 Hz  
 Maximal interaction energy 300 mJ  
 Radiation delivered by the COP/Ag waveguide

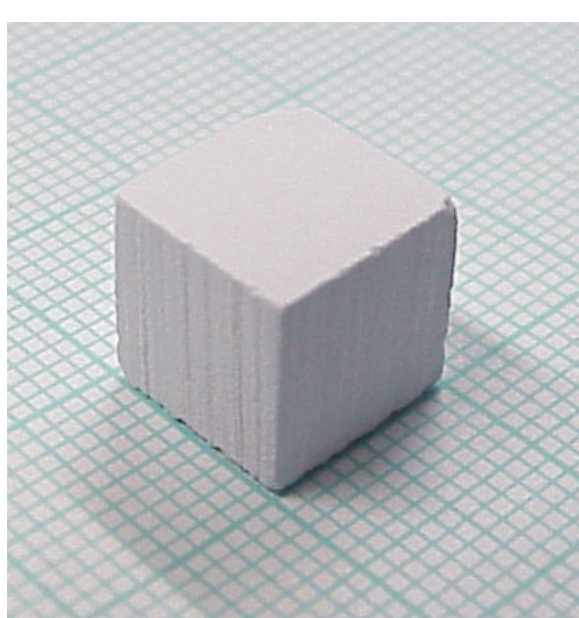
### Er:YAG

Flashlamp-pumped  
 Wavelength 2940 nm  
 Repetition rate 1 Hz  
 Maximal interaction energy 250 mJ  
 Radiation delivered by the COP/Ag waveguide

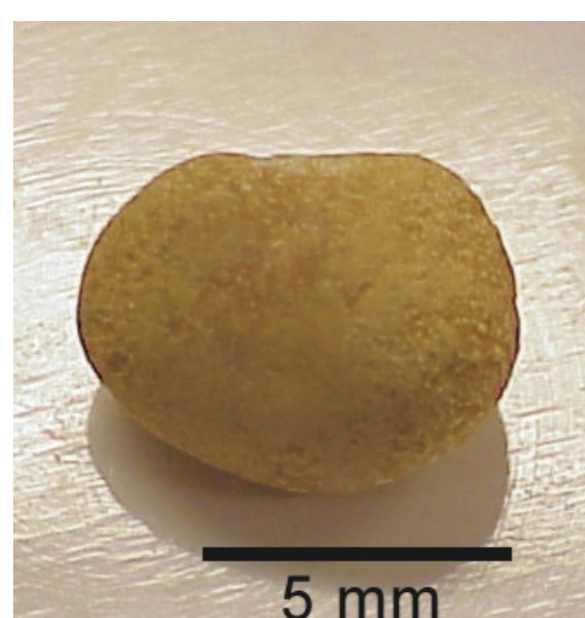
### Clinical Ho:YAG

Coherent Versa Pulse Power Suite Holmium  
 Wavelength 2100 nm  
 Maximal energy 4 J (power 100 W)  
 Pulsed free-running regime  
 Repetition rate 5 Hz - 25 Hz  
 Radiation delivered by the fibre

## Experimental samples

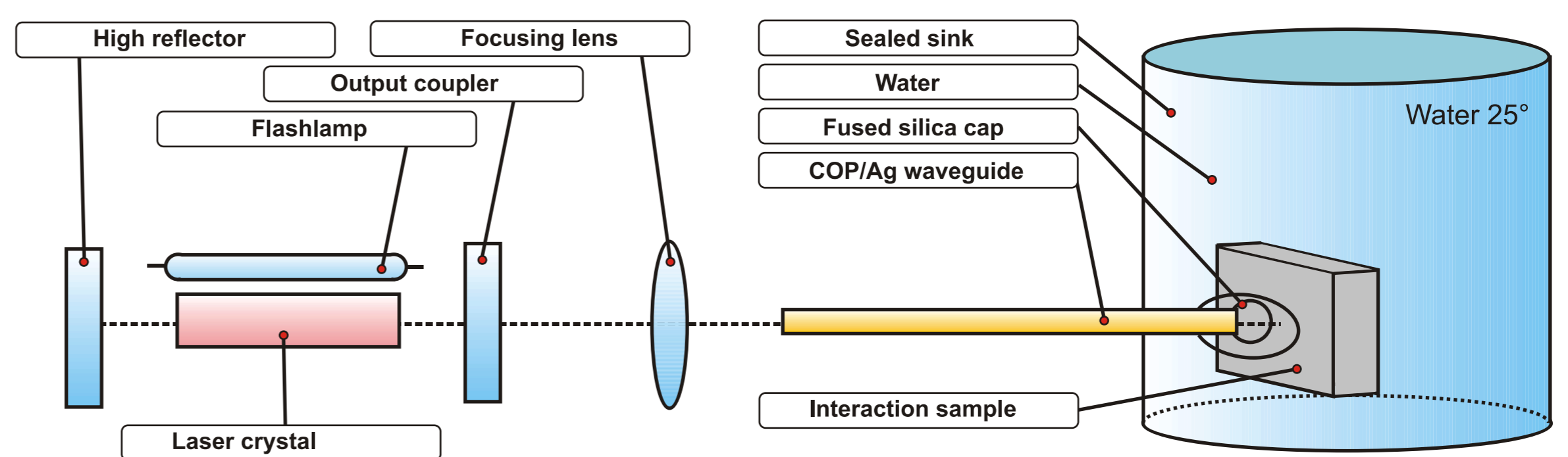


Artificial sample made from compressed plaster

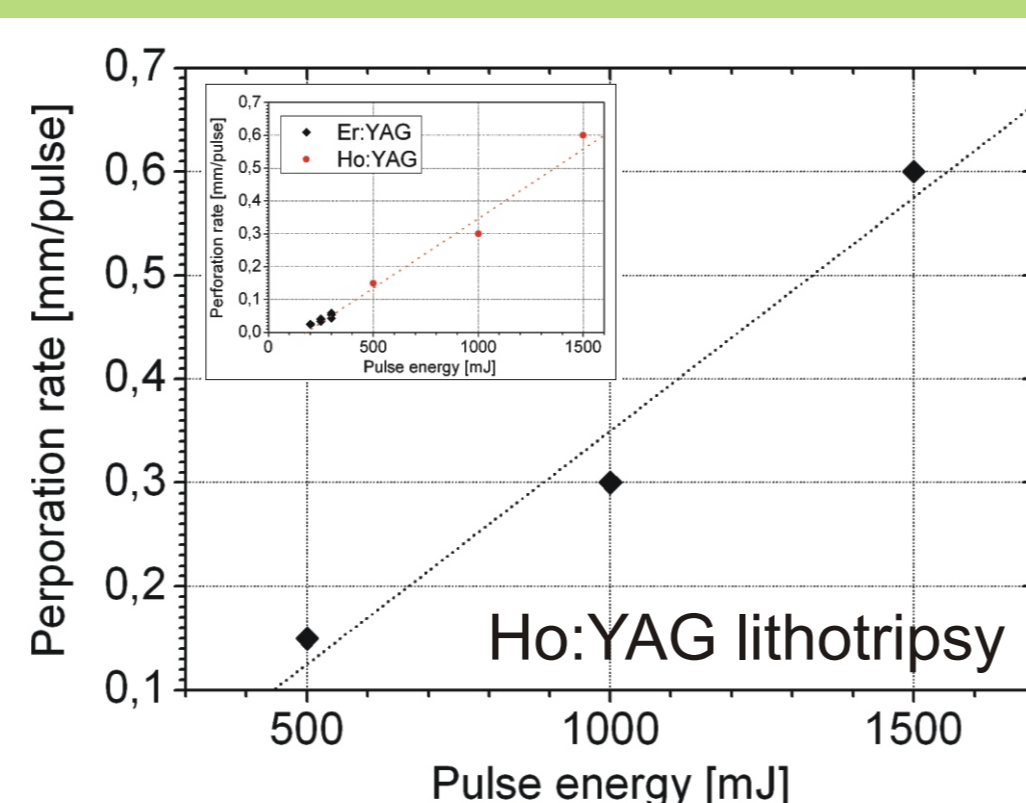
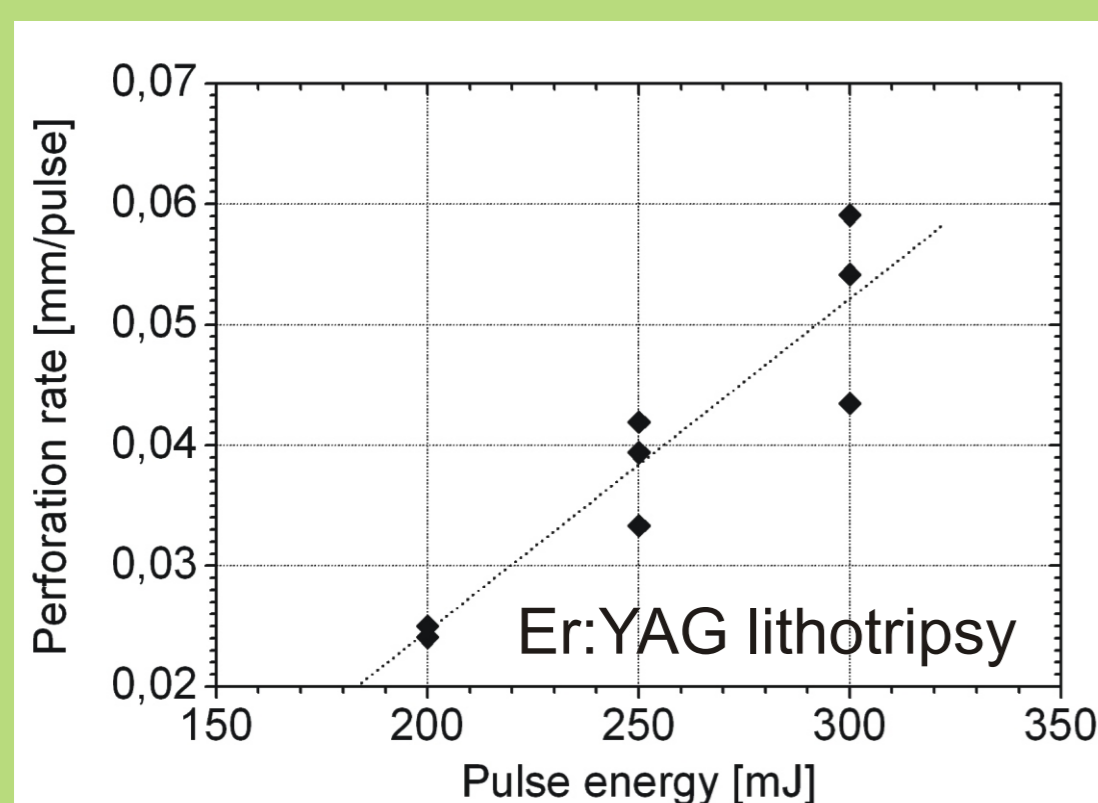


Human urinary stone

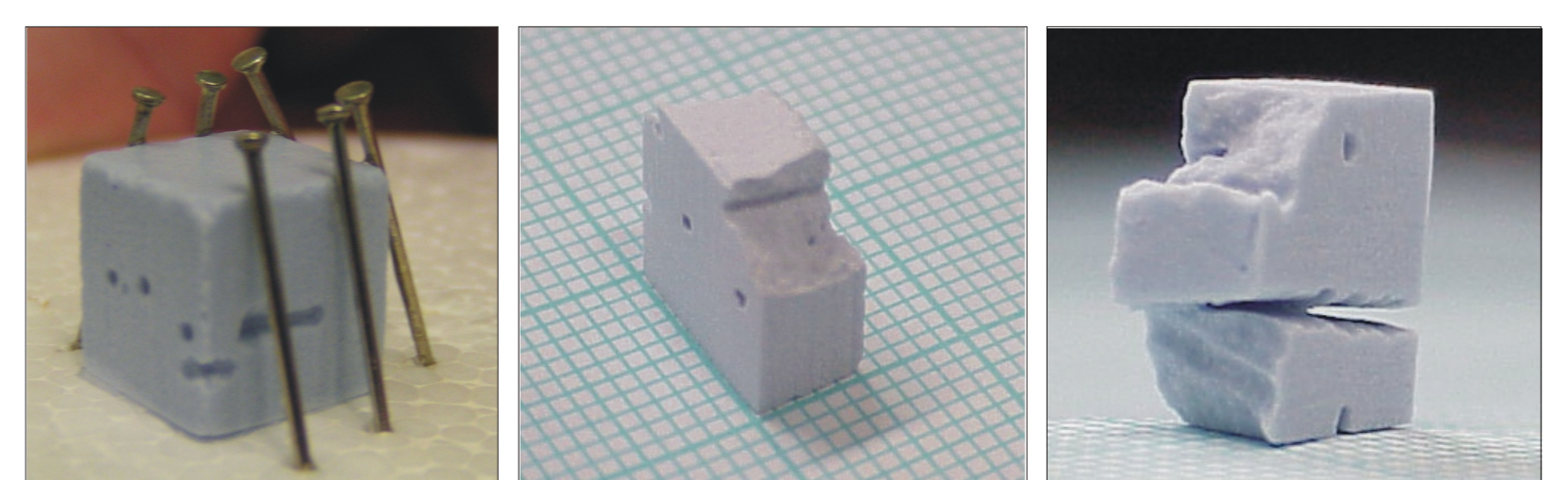
## Interaction Experiment Layout



## Experimental Results



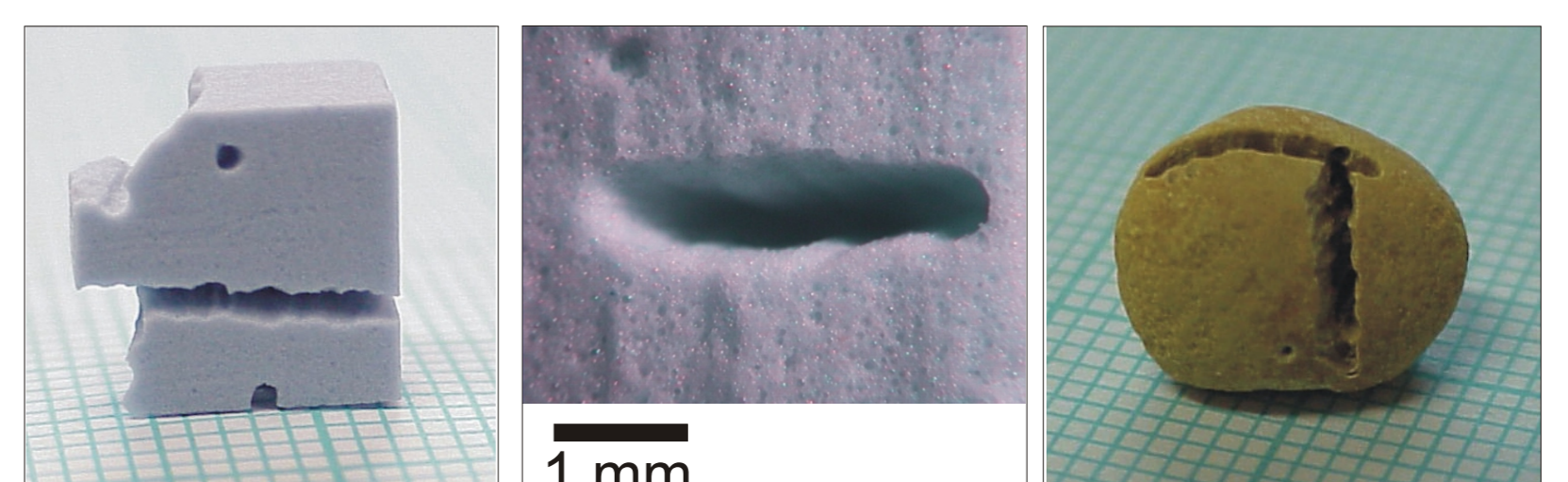
## Experimental Analysis



Sample perforation  
 Ho:YAG laser  
 120 pulses / 200 mJ

Sample perforation  
 Er:YAG laser  
 170 pulses / 250 mJ

Sample incision  
 Er:YAG laser  
 350 pulses / 250 mJ



Sample incision  
 Er:YAG laser  
 350 pulses / 250 mJ

Sample incision  
 Er:YAG laser  
 80 pulses / 250 mJ

Human sample incision  
 Er:YAG laser  
 220 pulses / 200 mJ

## Conclusion

Experimental evaluation of laser radiation (Ho:YAG or Er:YAG) interaction with artificial samples (compressed plaster) used as simulator of the real human urinary stones was performed in vitro. For each laser the number of pulses with certain energy needed for sample perforation was measured and analyzed. All lasers operated in different energy levels. From the results it can be evaluated that Er:YAG laser radiation is comparable with Ho:YAG laser in artificial samples perforation efficiency. Er:YAG laser radiation is preferable for precise cutting and ablation due to its absorption efficiency in tissue with high content of water. Therefore the Er:YAG laser is a good candidate for urology treatments (including laser-assisted lithotripsy) in comparison with Ho:YAG laser, which is now "gold standard" in clinical urology.

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