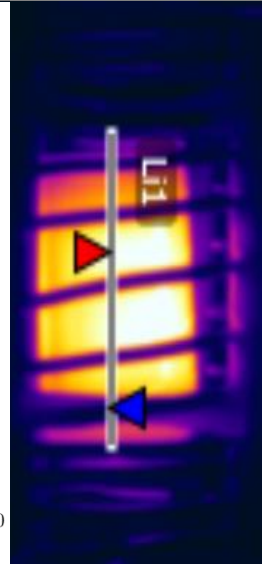
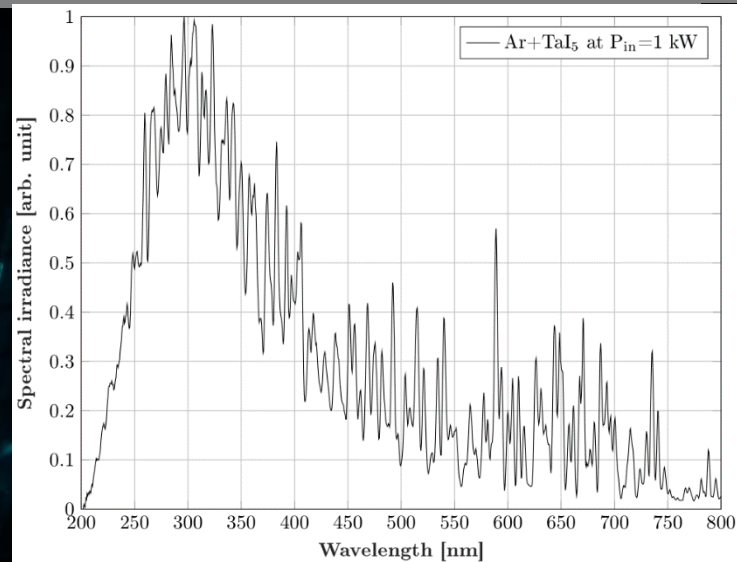
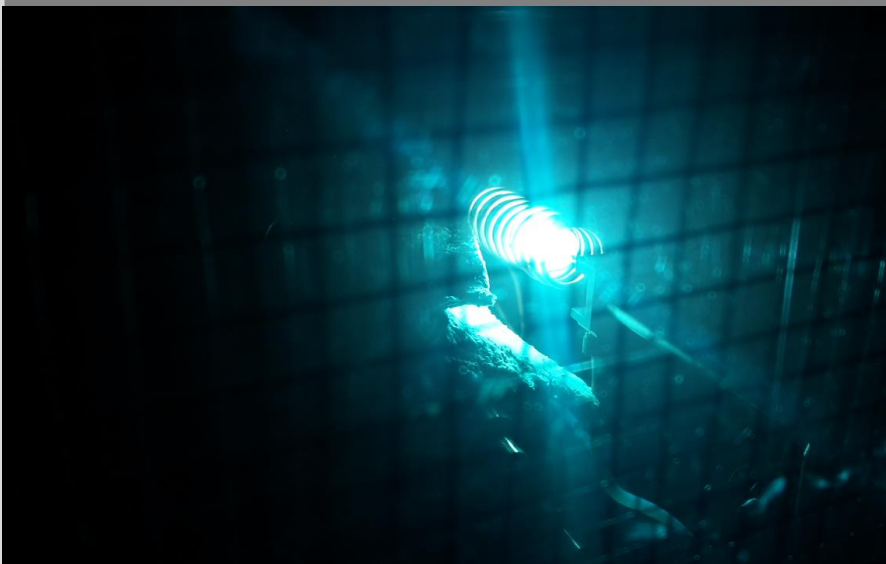


Medium Pressure Inductive Driven Lamps for UV-Water-Treatment

Tim Gehring, Qihao Jin, Rainer Kling

LIGHT TECHNOLOGY INSTITUTE, LIGHT- ECG - and PLASMA TECHNOLOGIES



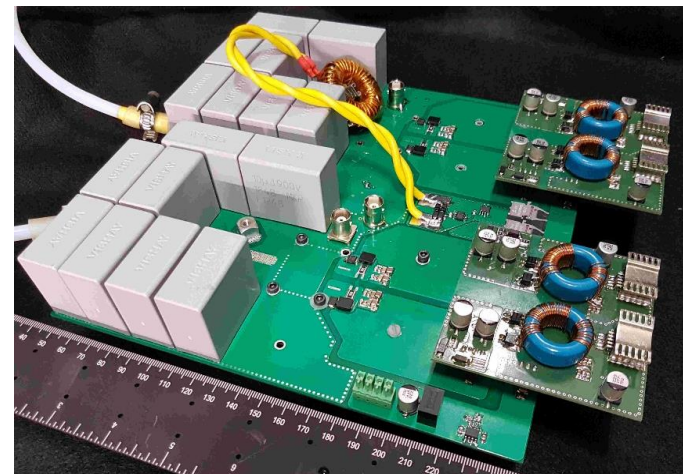
Motivation

- State of the art water reactors are Hg-Based
 - No efficient high intensity UV-LEDs $\lambda < 300$ nm

- SiC-FETs available
 - Possibility to build high efficient inverters
 - $P > 1$ kW at $f = 1-3$ MHz



[1]



[1] <http://www.ultraviolete.com/products/uv-systems-for-water-disinfection/aquaculture/hanovia-photon-pmd-range/>

Motivation

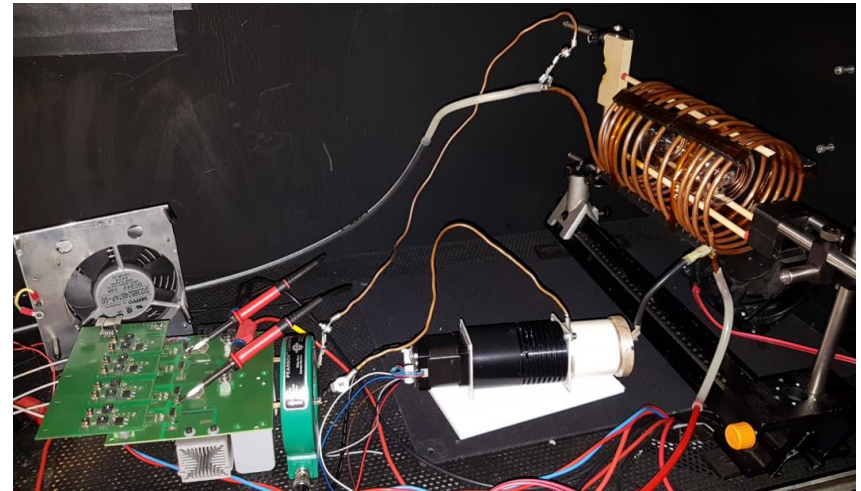
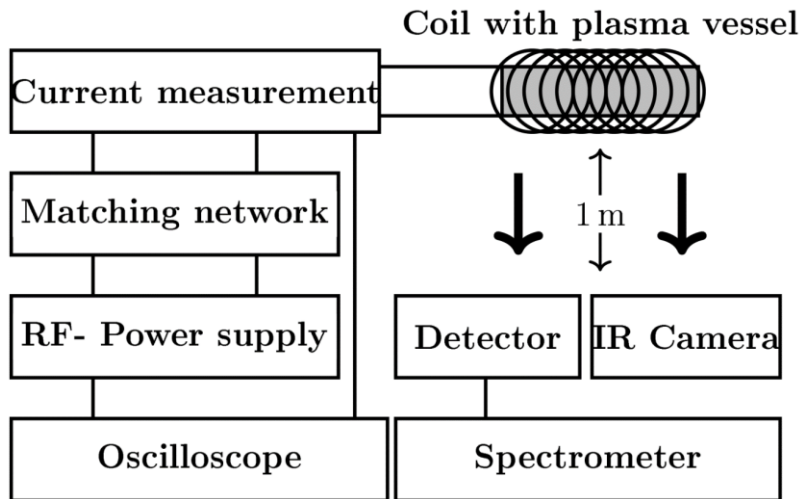
■ Lamp Development

- Toxicity
 - Non-toxic
 - Less toxic than Hg
- Electrodeless
 - Long lifetime
 - No electrode reactions
- High efficient in UV-range
 - Efficiency comparable to state of the art sources
- Medium pressure
 - UV- Output ≈ 200 W



Experimental Setup

- 1-3 MHz 2 kW Power supply (SiC) FET-inverter [2]

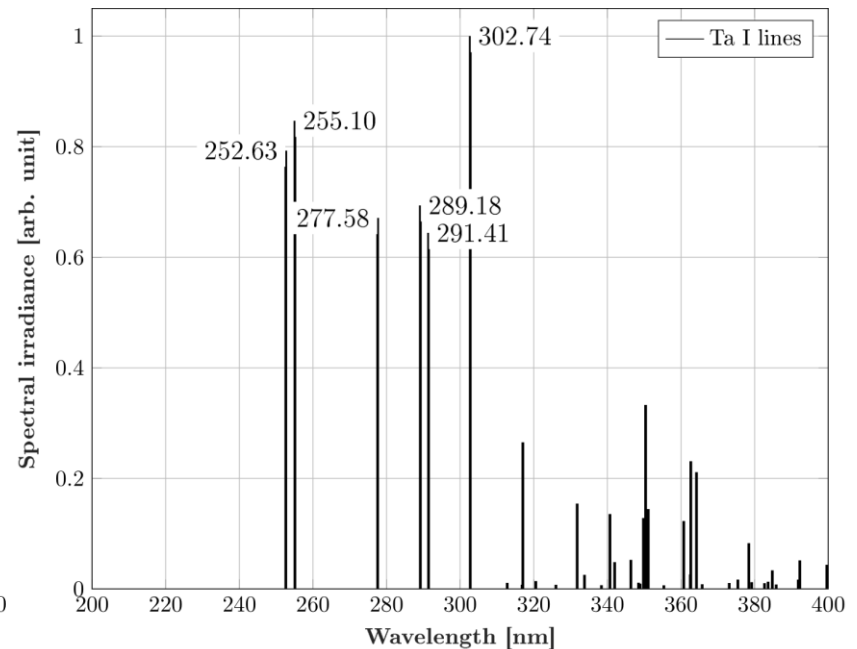
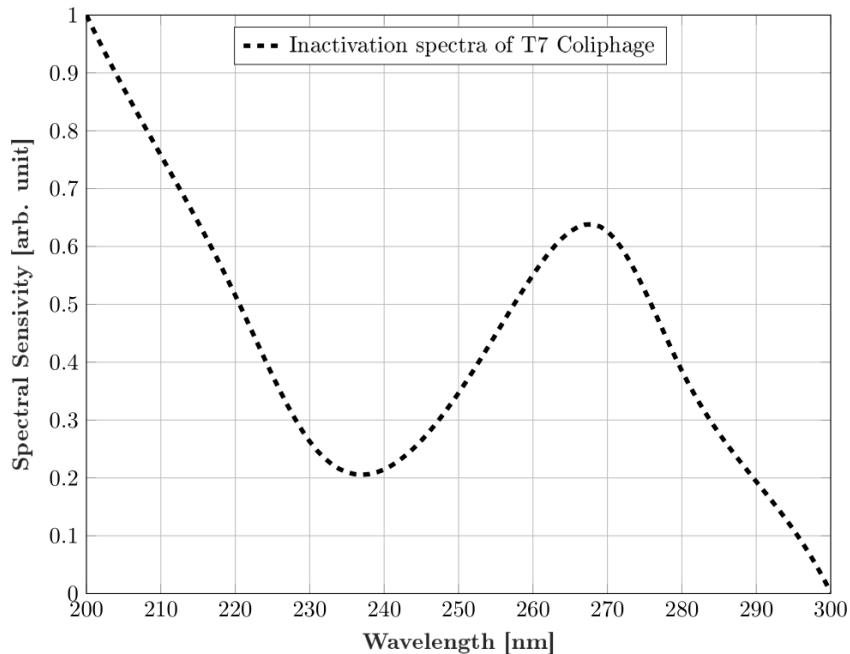


- Coil parameter: $l = 100 \text{ mm}$; $r = 35 \text{ mm}$; $n = 15 \rightarrow B_{\max} \approx 10 \text{ mT}$

[2] Denk et al. FRDS(on) vs. inductance: Comparison of SiC MOSFETs in 7pin D2Pak and 4pin TO-247 and their benefits for high power MHz inverters.

Filling Material

- Selection criteria: Compatible spectra for bacteria inactivation



[3] Beck, Wavelength-Specific Effects of Ultraviolet Light on Microorganisms and Viruses for Improving Water Disinfection

[4] National Institute of Standards and Technology

Filling Material

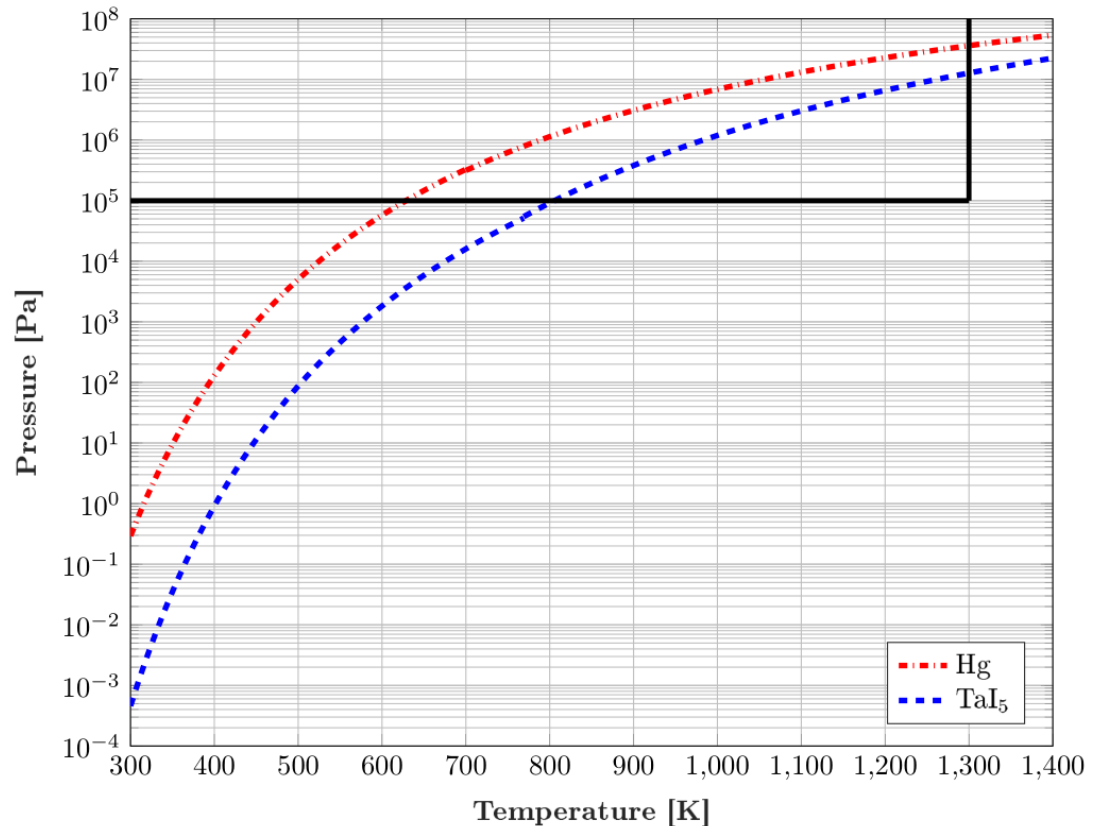
- Selection criteria: $P_{\min} \approx 10^5$ Pa in operation at $T_{\max} = 1300$ K

- Tantalum

- $P_{Ta} \approx 10^{-100}$ Pa

- Halide Compound

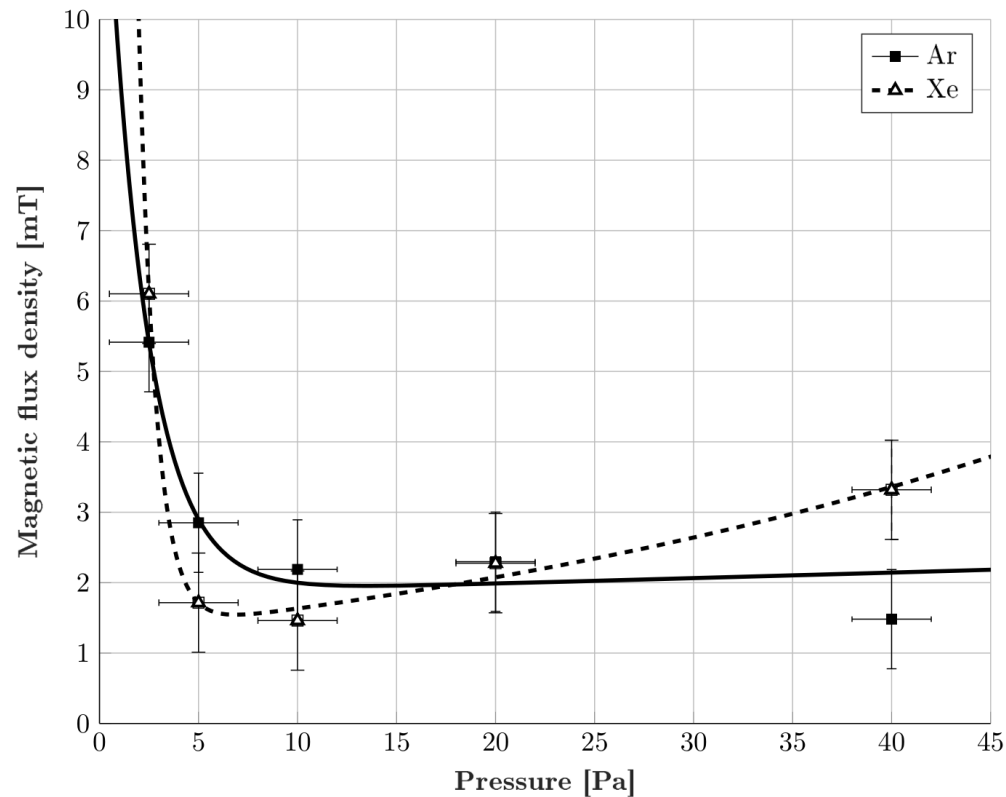
- $P_{TaI_5} \approx 10^7$ Pa



[5] Hansen et al. : Vapor Pressure of Metal Bromides and Iodides. With Selected Metal Chlorides and Metals

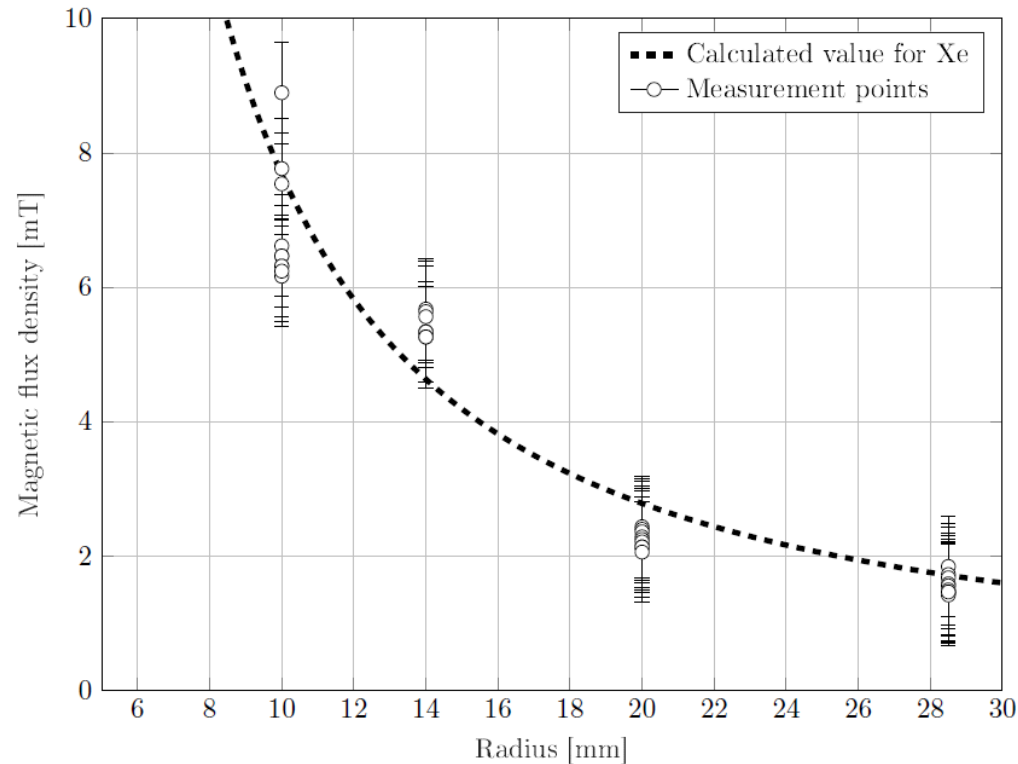
Filling Material

- Starting Gas: Selection according to the ignition field
 - Gas type: Xe, Ar
 - Gas pressure: $p \rightarrow B_{min}$



Geometry

■ Radius: Limitation by required magnetic field

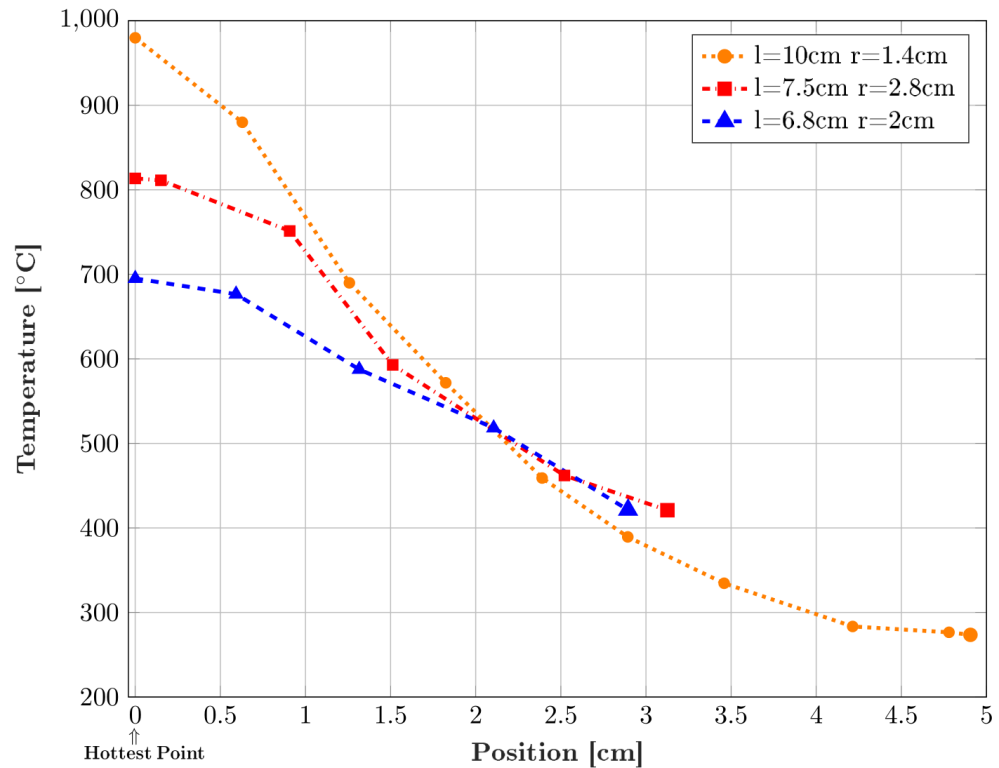
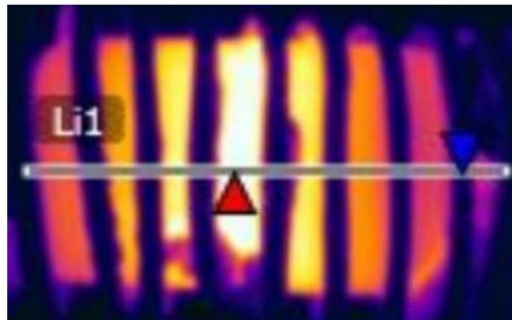
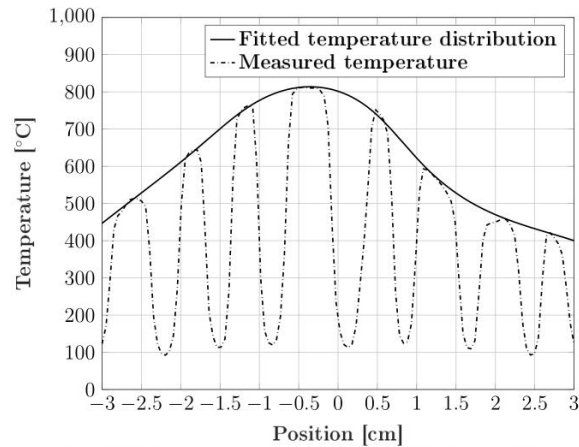


$$B_{breakdown} = \frac{B_0 p}{\omega R \left[\ln(A_0 \pi p R) - \ln \left(\ln \left[\frac{\gamma + 1}{\gamma} \right] \right) \right]} \quad [2]$$

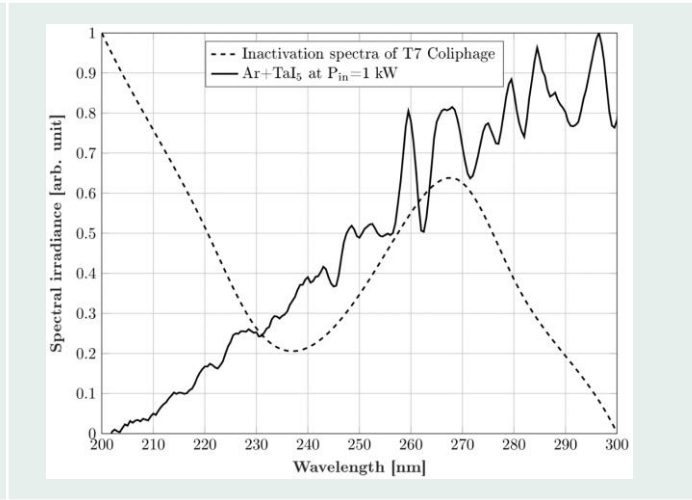
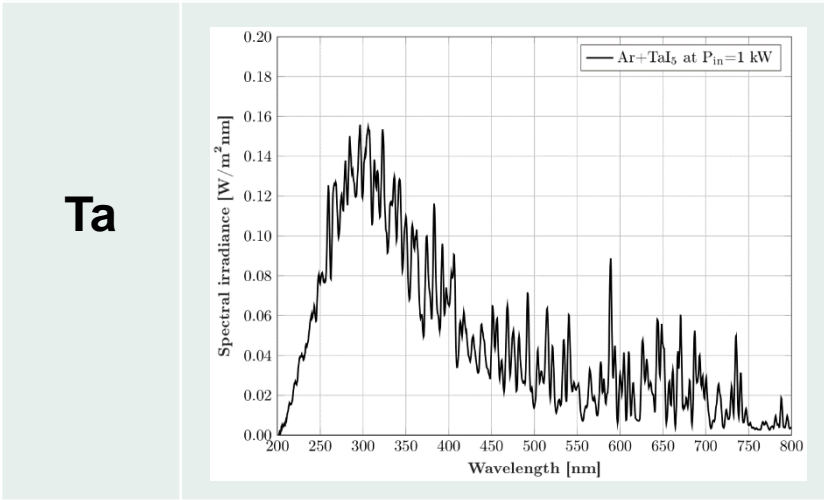
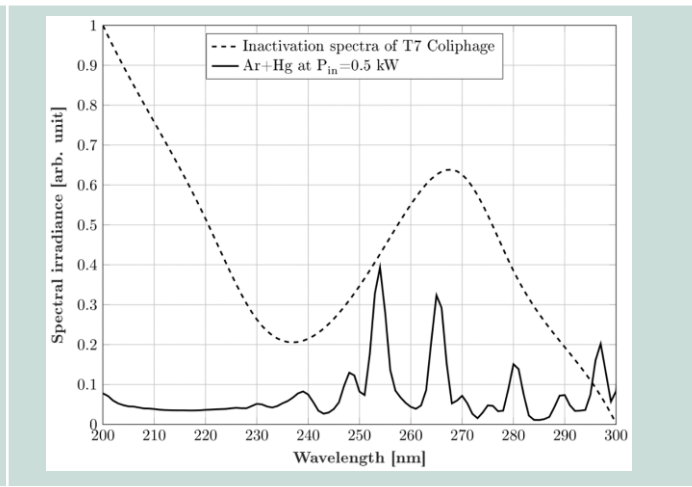
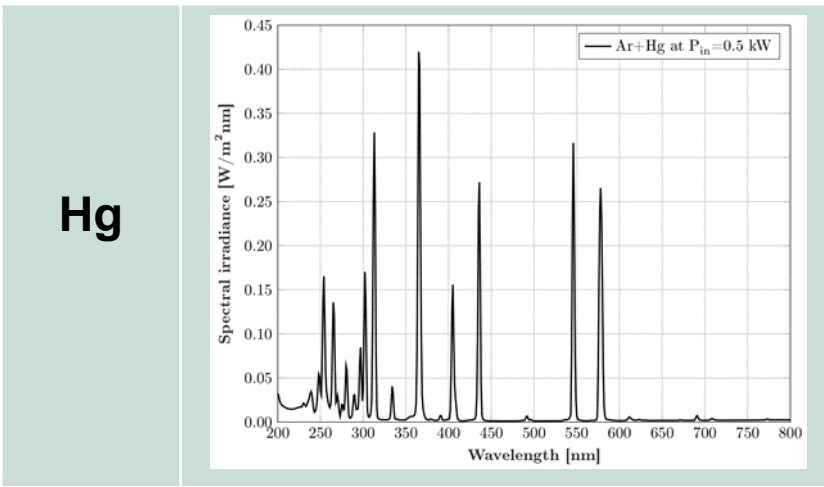
[2] Burm, Karel (2008): Breakdown magnetic field in an inductively coupled plasma. In: *Physics Letters A* 372 (41), S. 6280–6283. DOI: 10.1016/j.physleta.2008.08.037.

Geometry

Length: Limitation by temperature distribution



	Measured spectra	Spectra compared to inactivation spectra
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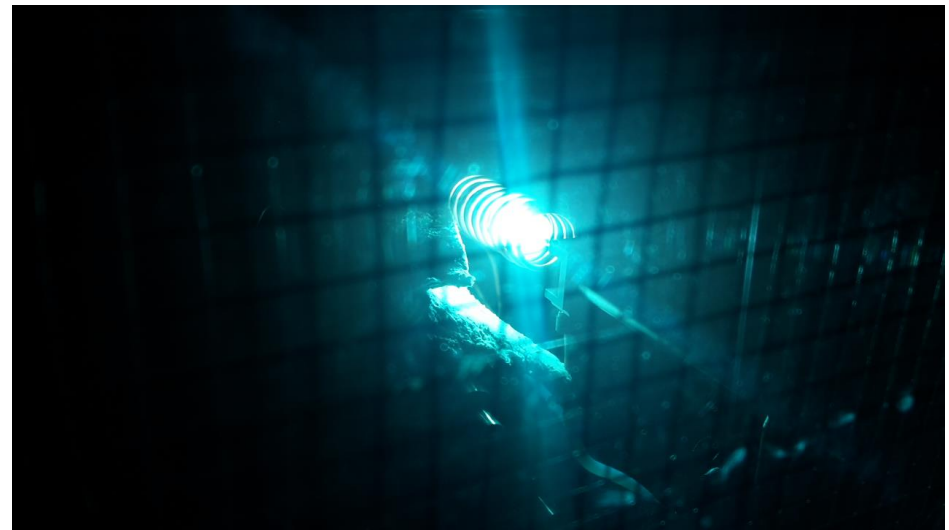
Results

■ Efficiency

	UV – efficiency (200-380 nm)	Weighted to action spectra (200- 300 nm)
Hg	16.4 %	8.0 %
Ta	19.9 %	8.1 %

Summary

- Hg free filling
 - Non-toxic
- Electrodeless
 - Long lifetime
- Medium pressure
 - ≈ 1 bar (calculated)
 - ≈ 200 W (200 - 380 nm)
- Efficiency
 - Equivalent to Hg





Thank you for your attention



Eco-UV is a research project funded under the European Union's Horizon research and innovation 2020 programme, Grant Agreement 641702

References

- [1] <http://www.ultraviolete.com/products/uv-systems-for-water-disinfection/aquaculture/hanovia-photon-pmdrange/>
- [2] Denk, F.; Haehre, K.; Simon, C.; Eizaguirre, S.; Heidinger, M.; Kling, R.; Heering, W. RDS(on) vs. inductance: Comparison of SiC MOSFETs in 7pin D2Pak and 4pin TO-247 and their benefits for high power MHz inverters. IET Power Electronics 2019, 8. doi:10.1049/iet-pel.2018.5838.
- [3] Beck, Sara Elizabeth, "Wavelength-Specific Effects of Ultraviolet Light on Microorganisms and Viruses for Improving Water Disinfection" (2015). Civil Engineering Graduate Theses & Dissertations. 153.
- [4] https://physics.nist.gov/PhysRefData/ASD/lines_form.html
- [5] S. Hansen, J. Getchius, R. Steward, T. Brumleve (2006): Vapor Pressure of Metal Bromides and Iodides. With Selected Metal Chlorides and Metals. 2. Aufl.: APL Engineered Materials, Inc.