Demonstration of optical pumping using a micro-fabricated Rb dielectric barrier discharge (DBD) lamp

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Previously, a low-power, mm-scale (~0.3 cm^3) Rb dielectric barrier discharge (DBD) lamp[1] was studied, in view of the development of a chip-scale atomic clock based on the traditional double-resonance (DR) interrogation scheme. Here, we report on the demonstration of optical pumping in a micro-fabricated Rb vapor cell (~0.3 cm^3), using such a DBD Rb lamp as a pump light source[2]. As a first step, we demonstrate Zeeman optical pumping in the M_z magnetometer configuration, using the setup shown in Fig. 1. We observe DR lock-in error signals using the DBD lamp, on both ^{85}Rb and ^{87}Rb isotopes. Comparison tests show that the pumping ability of the DBD lamp is comparable to or even better than that of a conventional glass-blown lamp (seen in Fig. 2), which indicates a high potential of the DBD lamp for the development of miniature atomic clocks, magnetometers and quantum sensors.

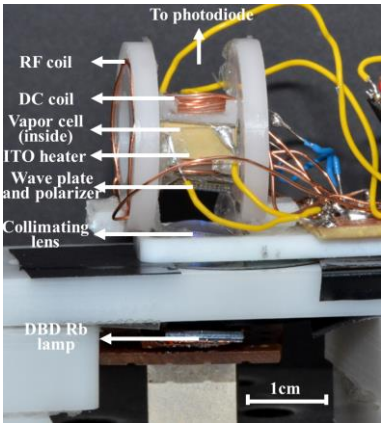

Fig. 1: Photograph of the M_z magnetometer test setup for the optical pumping demonstration.

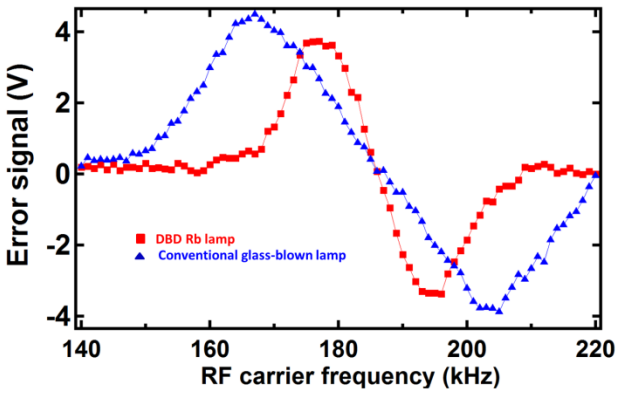

Fig. 2: ^{85}Rb DR error signals when using different Rb lamps. Both the DR signals were obtained without magnetic shields and at the same level of detection light power (about 6 μW).

[1] V. Venkatraman, Y. Pétremand, C. Affolderbach, G. Mileti, N. de Rooij, H. Shea, "Microfabricated chip-scale rubidium plasma light source for miniature atomic clocks", IEEE Trans. UFFC 59, p. 448-456, 2012.

[2] V. Venkatraman, S. Kang, C. Affolderbach, H. Shea, G. Mileti, "Optical pumping in a microfabricated Rb vapor cell using a microfabricated Rb discharge light source", App. Phys. Lett. **104**, 054104, 2014.