Status of an Optical Clock using Rb Two-Photon Transition in a Chip-Scale Vapor Cell at KRISS

Dai-Hyuk Yu[1], Myoungho Seo[1], Jae Hoon Lee[1], Hyun-Gue Hong[1], Jongchul Park[2]

[1]Korea Research Institute of Standards and Science, Daejeon, Rep. of Korea
[2]National NanoFab Center, Daejeon, Rep. of Korea

Email: dhyu@kriss.re.kr

We introduce our research in developing a miniaturized optical clock at KRISS using ^{87}Rb two-photon $5S_{1/2}$ to $5D_{5/2}$ transition. We use the conventional and chip-scale vapor cells. The transition provides a narrow spectral linewidth with potential applications in deployable miniaturized optical clocks. We obtain a resonance spectrum of the two-photon transition with a chip-scale rubidium vapor cell with the spectroscopy chamber size of 3×3×2.26 mm. The chip cell is made by 5-layer-waferbonding procedure for longer interaction lengths with the atoms. The window opposite to the laser beam entrance is dichroic-coated to reflect 778.1 nm while transmitting the fluorescence signal of 420 nm. The spectral signal is used for locking the laser frequency. The error signal is processed by an FPGA-based control system and is fed into the laser current and the AOM (Acousto-Optic Modulator) to construct a power stabilized frequency servo. Preliminary values of the stability at 1 second with conventional vapor cell and chip-scale vapor cell show 2×10^{-12} and 6×10^{-12}, respectively. We expect to improve in the future. By further miniaturizing the two-photon spectroscopy apparatus, we plan to develop a mobile optical frequency synthesizer platform combined with microcomb and photonic pre-stabilization technique for field applications[1, 2].

Fig. 1: Chip-scale vapor cell and Rb two-photon spectroscopy setup.

[1] D. Kwon, D. Jeong, I. Jeon, H. Lee, J. Kim, "Ultrastable microwave and soliton-pulse generation from fibre-photonic-stabilized microcombs", Nat. Comm., vol. 12, p. 381, 2022.

[2] D. Jeong, D. Kwon, I. Jeon, I.H. Do, J. Kim, H. Lee, "Ultralow jitter silica microcomb", Optica, vol. 7, p. 1108-1111, 2020.