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A chip-scale SERF atomic magnetometer based on micro-fabricated bi-planar coil

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In mobile magnetoencephalography (MEG) systems, hundreds of atomic magnetometer sensor heads are typically deployed, making the miniaturization of atomic magnetometers essential. The coils used for spin modulation and magnetic-field control are critical components of these devices. Here, using microelectromechanical systems (MEMS) technology, we have designed and fabricated a three-dimensional bi-planar coil with compact dimensions of 9 mm × 8 mm, as well as a heating coil measuring 9 mm × 6 mm. By combining femtosecond laser welding with MEMS processes, we also produced an alkali-metal vapor cell of only 6 mm × 4 mm × 3 mm. Building on the miniaturization of these components, we developed an integrated, micro single-beam spin-exchange relaxation-free (SERF) atomic magnetometer. This device combines the microfabricated bi-planar coil, the microfabricated heater chip, and the microfabricated alkali-metal vapor cell, and incorporates both a pump and a probe optical path. The probe housing, fabricated by laser sintering of glass-fiber material—measures just 43 mm × 12 mm × 15 mm, achieving an internationally leading level of integration among comparable magnetometers.

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