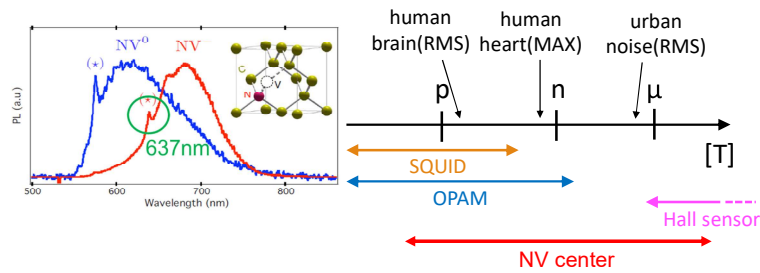


高感度ダイヤモンド量子センサ実現に向けた ダイヤモンド上ナノ構造のハイブリッド集積

R. Katsumi, S. Naruse, T. Hizawa and T. Yatsui
Toyohashi University of Technology

Nitrogen-Vacancy (NV) center in diamond



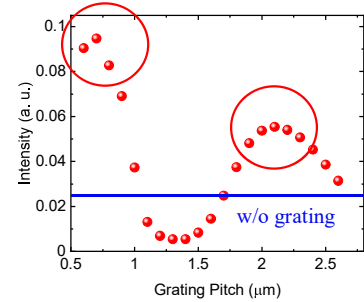
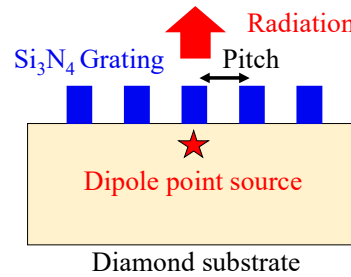
- Color center → Strong PL (red light)
- ○ Wide dynamic range of magnetic sensitivity (pT ~ μT)
- × High refractive index → Low light-extraction efficiency

N. Mizuochi *et al.*, *Nature Photonics* **6**, 299 (2012)
M. W. Doherty *et al.*, *New Journal of Physics* **13**, 025019 (2011)
Cohen, D. *IEEE Transactions on Magnetics* **11**, 2 (1975)

Numerical simulation

Si_3N_4 :

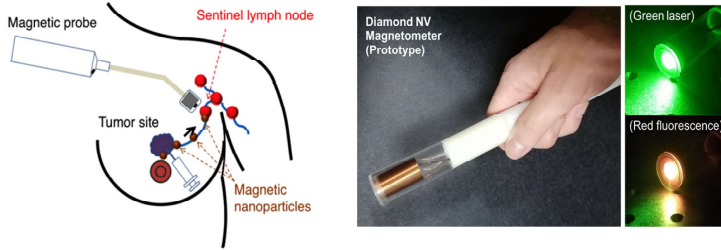
- Transparent for the NV emission (~ 700 nm)
- Developed fabrication technology



For Pitch = 0.7 μm (2.1 μm): x4 (x2.5)
⇒ Confirming efficient output of light radiated by NV centers

Research purpose

- (1) Develop **high-sensitivity magnetic sensor** with NV center



A. Kuwahata, TY, *et al.*, *Sci. Rep.* **10**, 2483 (2020)

- (2) Improve **light-extraction efficiency** (our experimental setup $\approx 10^{-11}$) of NV center using **grating coupler**

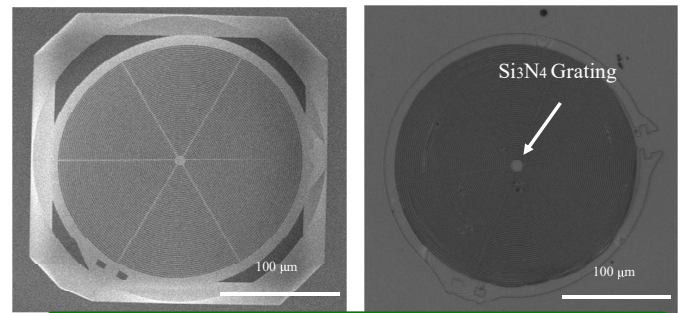
$$\eta \propto \frac{\Delta\nu}{C\sqrt{I_0}}$$

η : Minimal magnetic sensitivity of NV center

I_0 : PL intensity from NV center

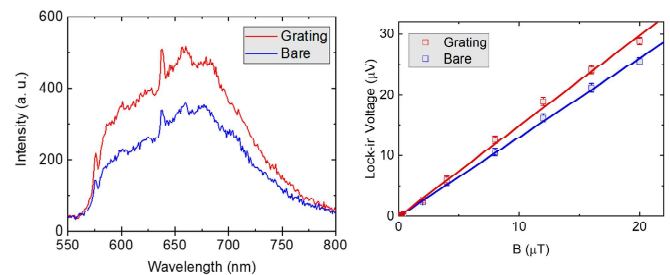
$I_0 \uparrow \Rightarrow$ Better magnetic sensitivity

Device fabrication



Succeeding in the integration of grating on diamond

Device characterization

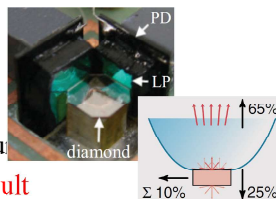


Succeeding in improvement of magnetic sensitivity

Improving the emission output from bulk diamond

□ Solutions for efficient collection

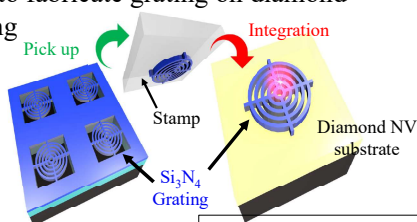
- Side collection, CPC lens: Bulky
→ Difficult to miniaturize
- Alternative/Attractive: Photonic structure
→ Fab on diamond: Technically difficult



D. Le Sage, *et al.*, *Phys. Rev. B* **85**, 121202 (2012).
T Wolf, *et al.*, *Phys. Rev. X* **5**, 041001 (2015).

In this work:

- New approach to fabricate grating on diamond
- Transfer printing



R. Katsumi, *et al.*, *Optica* **5**, 691 (2018)

Publications

- A. Kuwahata, T. Kitaizumi, K. Saichi, T. Sato, R. Igarashi, T. Ohshima, Y. Masuyama, T. Iwasaki, M. Hatano, F. Jelezko, M. Kusakabe, T. Yatsui, M. Sekino, *Scientific Reports*, **10**, pp. 2483, 2020
- T. Kitaizumi, A. Kuwahata, K. Saichi, T. Sato, R. Igarashi, T. Ohshima, Y. Masuyama, T. Iwasaki, M. Hatano, F. Jelezko, M. Kusakabe, T. Yatsui, Masaki Sekino, *IEEE Transactions on Magnetics*, **57** (2), pp. 5100405, 2021
- R. Katsumi, T. Hizawa, A. Kuwahata, S. Naruse, Y. Hatano, T. Iwasaki, M. Hatano, F. Jelezko, S. Onoda, T. Ohshima, M. Sekino, and T. Yatsui, *Appl. Phys. Lett.* **121**, 161103 (2022).

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