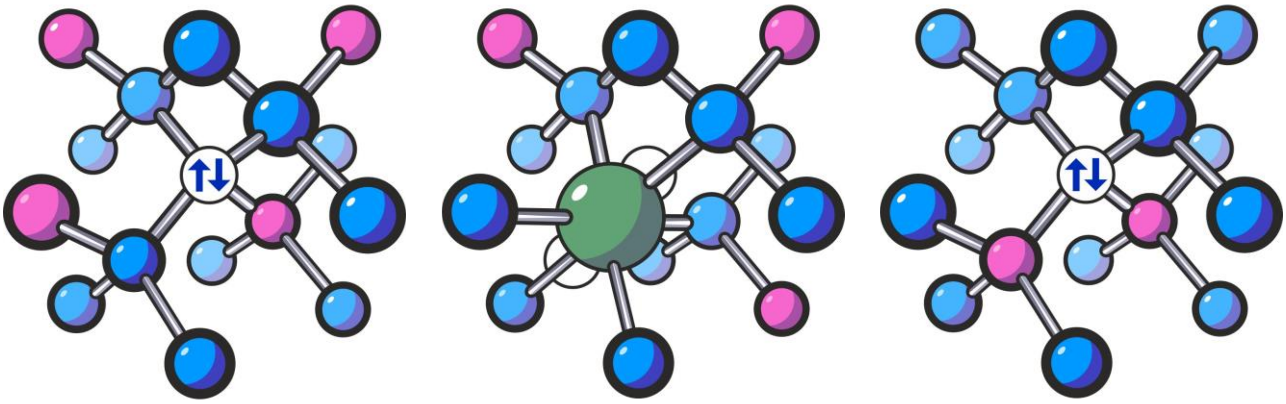
DIAMOND COLOR CENTERS IN QUANTUM SENSORICS AND QUANTUM COMPUTING*

E.I. LIPATOV[1,2]

[1]*Tomsk State University, Tomsk, Russian Federation*
[2]*Institute of High-current Electronics SB RAS, Tomsk, Russian Federation*

Due to development of synthesis technologies and radiation-thermal treatment of diamond, it has become possible to obtain diamond samples with a certain impurity-defect composition at industrial scale [1]. Some color centers in diamond, such as NV^-, N_2V^0, SiV_2^- etc. (see Figure 1), are characterized by electronic transitions in the visible and near-infrared ranges, spin splitting of electronic levels, singlet and triplet subsystems, and intercombination conversion between them. Therefore, these diamond color centers are used in quantum sensorics and quantum computing.



a) b) c)

Fig.1. Diamond color centers used in quantum sensorics and quantum computing. a) NV^- center, b) SiV_2^- center, b) N_2V^0 center. Carbon atoms are indicated in blue, nitrogen in red, silicon in green, and white circles are vacancies.

Quantum sensors based on diamond color centers have high potential applications in devices such as magnetometers, gravimeters, temperature sensors, accelerometers and gyroscopes. Such quantum sensors are potentially applicable in inertial navigation systems of unmanned aerial vehicles [2].

Methods of measuring their states have been developed for diamond color centers used in quantum sensors. Therefore, these centers are suitable for the role of qubits for quantum computing [3]. Due to the presence of a large number of different structural defects in the diamond lattice that create "quantum noise", the maximum possible distance between the qubits – diamond color centers – is limited. For example, for qubits based on NV^- centers, multi-qubit quantum operations (gates) are possible only using magnetic dipole-dipole interaction, which limits the maximum distance between NV^- centers in the range of 10-20 nm. In this case, there is a problem with the individual addressing of qubits by laser radiation in the spectral region of the phonon wing absorption of the NV^- center in the range of 500-630 nm.

This review report is devoted to the consideration of the current situation in quantum sensors and in quantum computing based on diamond color centers, the current direction of research and development, problems and possible ways to overcome them.

REFERENCES

[1] I. A. Dobrinets, V. G. Vins, A. M. Zaitsev, “HPHT-Treated Diamonds“, Springer Series in Materials Science, 181, p.1-270, 2013

[2] S. Chouaieb, L.J. Martínez, W. Akhtar, et al., “Optimizing synthetic diamond samples for quantum sensing technologies by tuning the growth temperature“, Diamond and Related Materials, 96, p. 85-89, 2019

[3] S. Pezzagna, J. Meijer, “Quantum computer based on color centers in diamond“, Applied physics review, 8, 011308, 2021

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