Spin polarization dynamics in dilute nitride semiconductors

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In the recent years there has appeared a new concept of application of dilute nitride semiconductors in spintronics due to the unique spin dynamics in this material system and the so called spin filtering effect which is directly connected with the paramagnetic defects present in this material system [1,2].

One of the main problems of modern spintronics is to maintain a spin polarization at room temperature for sufficiently long time to perform spin states manipulation. Due to the presence of deep paramagnetic centers in dilute nitride semiconductors, the spin dependent recombination of electrons occurs in this material system [2]. Under the excitation by circularly polarized light this effect significantly elongates the lifetime of electron spin polarization (~2 ns at room temperature) in comparison to the classical III-V semiconductors. This unique property of spin dynamics in dilute nitrides was for the first time observed in 2005 and since that moment the significant progress in understanding of this phenomenon has been made. However, there are still some unexplained aspects of this effect, which are the subject of this studies.

In the available literature the temperature dependence of the spin dynamics in dilute nitrides is not explained. The experimental results show that the spin polarization lifetime is significantly longer at room temperature then at cryogenic ones [1,3]. The theoretical description of the spin polarization dynamics in dilute nitride semiconductors is restricted to the phenomenological model proposed by Kalevich [4]. This model, based on a few level rate equation system explains with success the essential features of spin filtering effect in dilute nitride semiconductors. However, it does not take into account the temperature influence and the presence of non-paramagnetic defect states on spin polarization dynamics. Therefore it is not able to reconstruct and explain the experimentally observed temperature dependence of the spin polarization lifetime.

In this work we show that taking into account the presence of shallow localizing states (which are typical for this material system) it is possible to explain why the spin polarization lifetime is significantly shorter at low temperature than at room temperature. Moreover we can explain excitatin power dependence of spin polarization life time. The results of modified Kalevich model [4] are compared with the experimental results whit very good agreement.

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