Local arrangement of the Ni clusters deposited on Bi_2Te_3 surface - STM and STS investigations

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Motivation

Many papers concerning Bi_2Te_3 band structure studies through calculations and photoemission experiments have been published in recent years. This compound has also attracted attention because of its potential application in the micro-fabrication of integrated thermoelectric devices [1]. The STM/STS investigations of Bi_2Te_3 surface were presented in our previous paper [2]. The results of Ag clusters' growth on bismuth telluride surface were presented in [3]. We observed creation of separated Ag clusters with heights of 2-3 monolayers. In this paper we present the results of investigation of Ni cluster deposition. Separated clusters of magnetic materials could create closed magnetic domains in nanometer scale. The main goal of work reported here was to characterize Ni clusters' topography and electronic properties. In future we are going to study $Ni@Bi_2Te_3$ system using MFM (magnetic force microscopy) method.

Substrate

Bi_2Te_3 is a narrow band gap semiconductor with indirect E_g reported as ~0.15[eV] [4]. It crystallizes as a layered structure in rhombohedral, D_{3d}^5 (R3m) space group. Individual layer contains only one type of atoms - Te or Bi. Cleavage along (111) plain produces atomically flat terraces with islands or hills whose heights are determined by the layered crystal structure, given in [2]. The surface changed during annealing and became more varied with elongated time of heating. We observed creation of multi-terraced surface, but still the differences in heights of particular terraces corresponded to the basic crystal structure. Figure 1 presents sample pictures of freshly cleaved surface and the surface after annealing.

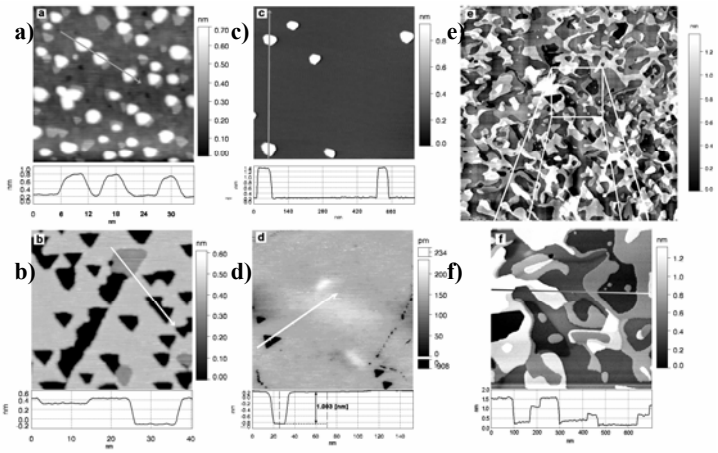

Fig. 1. Surface of Bi_2Te_3: a) and b) after cleavage, c) and d) after annealing at ~300°C, e) and f) after elongated annealing at 150°C.

Results and discussion

Figure 2 shows surface of the Bi_2Te_3 after deposition of adequately 0.8, 1.6 and 3.2 monolayers of Ni. It is clearly seen that with low coverage Ni has created separated thin ~0.6[nm] islands of different sizes. When the amount of deposited material rose, islands started to coalesce. Deposition of 3.2 ML induced a layer by layer like mode of growth whereas wetting layer creation was a rather dominating process before.

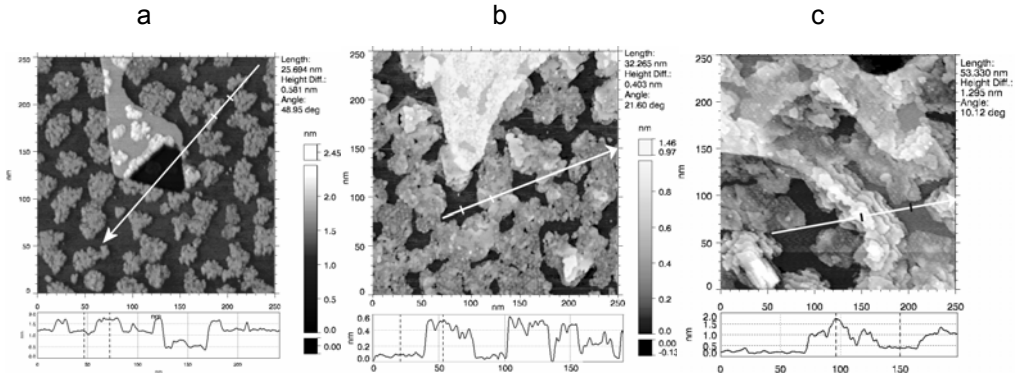

Fig. 2. Ni deposited on Bi_2Te_3: 0.8, 1.6 and 3.2 ML.

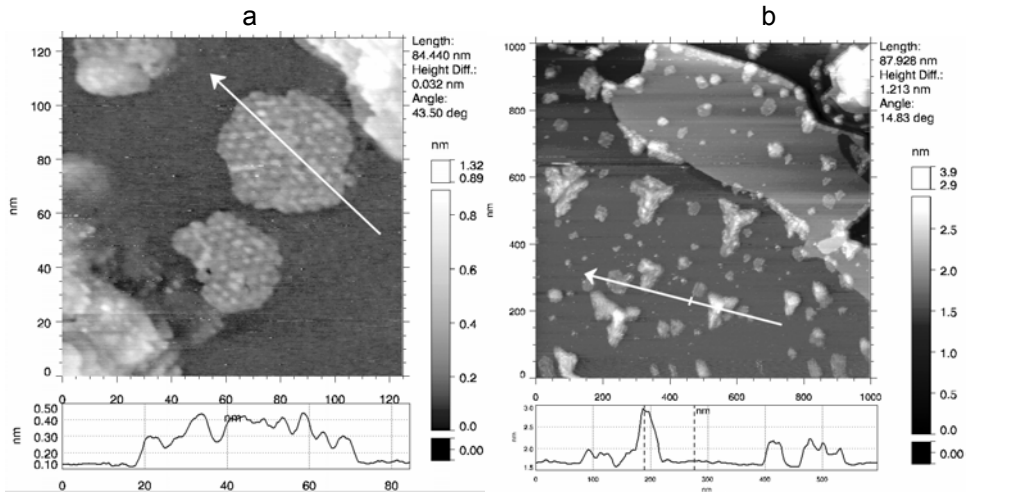

Fig. 3. Ordered arrays of Ni clusters created on Bi_2Te_3 surface.

As it is shown in Figure 3 we observed creation of interesting features by the deposited Ni. Internal structure of some clusters revealed periodic arrangement when their height was about 0.5[nm] (Fig. 3a). We suspect that it was caused by lattice mismatch effect since the lattice constants of Ni and Bi_2Te_3 are different. The heterostructure period constant was ~5[nm]. The same effect is also visible in Fig. 2b. With low coverage, besides ordinary flat clusters, Ni was organized in structures of tree-fold symmetry (Fig 3b). They were growing in dendrite mode rather than layer-by-layer - even though they were relatively high (1.2-1.6[nm]). The reason for such clusters' behavior is still to be investigated.

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