# Quantum Oscillations of the Rashba Spin-splitting Compound BiTeI

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## Introduction

BiTeI has attracted considerable interest over the past years due to the observation of a large Rashba spin-splitting of the electronic bands. Another peculiarity of this compound is that the effect has been, at least initially, proposed to be purely bulk in nature [1]. Recent photoemission (ARPES) experiments indicate possible charge accumulation at the terminated layer that give rise to a surface electron system distinct from the bulk. Single crystals of BiTeI were grown by Bridgman and transport methods. From Hall coefficient and optical spectroscopy, we found that there is a systematic difference in the carrier concentrations, hence in the positions of the Fermi level, between the samples grown by different methods [2]. Given the particular sensitivity of the ARPES technique to the surface, we investigate the Fermi surface in the bulk by means of the tunnel diode oscillator (TDO) technique. Quantum oscillations are measured in a temperature range from 1.3 K to 100 K in short pulsed magnetic fields up to 65 T.

## Results and Discussion

**Figure 1** (a) shows a TDO frequency shift, which is directly proportional to resistivity, at $T$ = 1.35 K and 80 K for **H || c,** for a sample grown by Bridgman method. Quantum oscillations are clearly observed in the high field region up to 80 K. However, a closer look at the data reveals a few periods of a different oscillation in the low field region. Since only few oscillations are observed in the low field region, the Fast Fourier Transform (FFT) spectra do not show peaks. Therefore, the frequency is directly estimated from the data to be on the order of 8 T. This very low frequency disappears around 15 T, reaching the quantum limit. The high frequency oscillations can be observed as high as 80 K, implying a very light effective mass of carriers. The FFT spectra reveal a clear peak at 376 T as shown in Fig. 1 (b). The effective mass can be estimated from Lifshitz-Kosevich (LK) formula by fitting the temperature dependence of the FFT amplitude. The estimated effective mass is ~ 0.17 $m_0$, where $m_0$ is the bare electron mass.

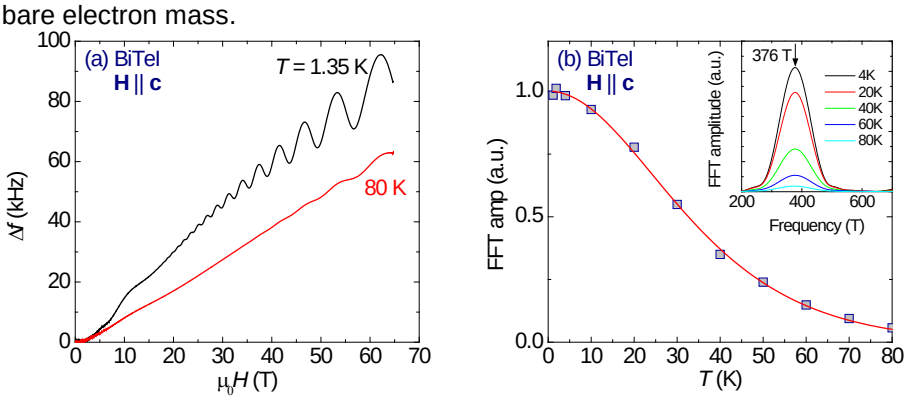


**Figure 1** (a) The measured TDO frequency shift, $\Delta f$, at $T$ = 1.35 and 80 K along **H || c**. Samples were prepared by Bridgman method. (b) Temperature dependence of the FFT amplitudes. Solid line represents LK fit.

The same measurements were performed on another sample grown by transport technique. The results between the two separate runs were very similar and reveal some noticeable differences between the samples grown by different methods: the low-frequency oscillation is absent and the carriers are almost 30% lighter in the transport grown sample, i.e. with lower carrier concentration.

## Conclusions

An important finding is that the high-frequency, high-magnetic-field oscillations appear to depend only on the component of the magnetic field perpendicular to sample surface [2], indicative of a highly 2D Fermi surface. Moreover, we also observe a rapid suppression of oscillations with tilting angle of the magnetic field. Therefore, it is possible that they originate from surface carriers. On the other hand, the high-frequency oscillations may correspond to the outer bulk Rashba-split Fermi surface, while the low frequency to the much smaller inner Fermi surface, respectively. The absence of the low frequency in the low-carrier samples may then be due to the fact that the Fermi level is situated below the crossing point of the two split bands.

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## References

[1] Ishizaka, K., *et al*., Nature Materials **10**, 521 (2011).
[2] Martin, C., *et al*., arxiv: 1208.5523 (2012).