Teaching Reform of Solid State Physics Course for Material Physics *

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***Abstract*—In this paper, the position and role of solid state physics course is introduced in undergraduate course teaching system for materials physics specialty. According to the relation with other course, teaching reform and practice of contents and means are discussed and development direction of educational reform is introduced.**

Keywords—solid state physics; teaching; teaching reform; materials physics

I. INTRODUCTION

In the course system of material physics specialty, solid state physics has a very important position as the connection of basic course and specialty course. As a combination course of theory and application, study of it can not only broaden the basis of professional knowledge but also contact the forefront of the latest achievements of science and technology. As we are faced with the continuous appearance interdisciplinary fields and associated study curricula in natural and engineering sciences (biophysics, mechatronics, etc.), a compact text in solid state physics would be appreciated by students of these disciplines as well. So, study of solid state physics is very important for students' innovation spirit and ability of active learning and acceptting the information.

II. SIGNIFICANCE, NECESSITY AND OBJECTIVE OF TEACHING REFORM FOR SOLID STATE PHYSICS COURSE

A. the Status and Characteristics of Solid State Physics course

Solid state physics is established in the 1940s and 1950s. After nearly half a century development, metal physics, lattice dynamics, semiconductor physics, dielectric physics superconductivity physics, magnetic physics, electronics physics, etc., especially for condensed matter physics are derived from it[1,2]. Solid state physics has become one of the most important subjects in the field of physics and closely linked with condensed matter physics and materials science. Solid state physics plays a key role in the contemporary development of high technology and development of many new fields of science and technology are based on solid state physics. Moreover, basic concept, theory and experimental techniques which developed from solid state physics steadily infiltrate into and promote the development of other related subject.

B. Training Objectives of Solid State Physics

Improving the training quality of students is the basic point of higher education reform in China and comprehensive improvement of the basic qualities and skills of students is the central task of it.[3] A true college student must be a master of certain knowledge and ability structure. Knowledge is the foundation of ability, ability is different expression forms of knowledge which are used at different occasions. Basic objective of solid state physics is to train the modern and creative science and technology talents which not only has the basic theory, but also has the innovation ability.

With the development of science and technology, contents and teaching methods are difficult to meet the requirement of discipline development and student training objective. Students is not interested in this course and difficult to master the knowledge of it because of the characteristic of solid state physics, e.g., complex content, more knowledge points; complex formulas. In order to solve the contradictions of" teaching " with " learning " and meet the requirement of discipline development, we undertake these reform from teaching content and teaching method.

Traditional college teaching mainly instructs students knowledge, in some degree, it neglects students' competence of comprehensive quality. The teaching of solid state physics should be changed from knowledge centered education to all sided quality centered one, which attaches more importance to the students' scientific ability. Overemphasizing knowledge education and ignoring quality education is still a problem existing in the current teaching for engineering students. Having a good grasp of scientific methodology is of great benefit for students to learn new knowledge, new skills, and more importantly to think independently.

Therefore, three kinds of reform for teaching contents and teaching methods are undertook as follows: first, by increasing relation knowledge with other courses, strengthen the integrity of teaching contents. Secondly, carefully select teaching contents. That is, focuses physics theory, concept and description of model of physics. In order to simplify the teaching process and stress difficulty, avoid deriving the complex mathematical formula. Finally, By adopting advanced teaching methods and view, focus on training students' innovation ability and the formation of scientific thought.

III. REFORM OF THE TEACHING CONTENTS

A. Increasing Relation Knowledge with Other Courses

Owning to its theoretical property and systematic feature, abundant and abstract content, solid state physics have high

demands on both students and teachers. General requirements of content reform for Solid state physics must adapt to the new requirements of social changes for higher education and the diversity of the needs of our society, and fully represent the holy responsibility and the educational ideology on the basic of students.

The aims of the courses are to search for the balance among knowledge, ability and quality structure and to make sound foundation for the long-term development of students. Thus the scope of knowledge need to be expanded as the traditional solid state physics content is improved. This kind of teaching reform could not only widen the horizons of students, enhance the knowledge of solid state physics, but also achieve individualized instruction in accordance with students' aptitude.

Solid state physics is based on theory physics and lots of knowledge in other course are used in it, such as, quantum mechanics, electrodynamics, statistic physics. For the introduction of theory physics knowledge, lots of students can not fully understand the teaching contents and not willing to learn. In view of this situation, before each new chapter, we take some time to review the learned knowledge of physics which is related to the content of this chapter This kind of reviewer is not simple re-teaching, but summary based on contents, viewpoint, method and conclusion. By introducing knowledge of electrodynamics, statistic physics quantum mechanics into solid state physics, enable students to achieve new insights through restudying old teaching contents.

In the chapter of ion long optical wave, we lay a solid foundation to study the electromagnetic properties of ionic crystals by teaching related knowledge of electrodynamics and systematically expounded the origin of Maxwell equations. In the chapter of lattice wave, review with students the knowledge of elastic waves and focused characteristics of elastic wave. By doing this, we are ready to study properties of lattice wave and comparison of elastic waves with lattice waves, etc. Because of making the necessary preparations, students no longer fell difficult when old knowledge are used and smoothly complete the learning transition from the old to the new knowledge.

B. Selection and Supplements of Teaching Contents

With the emergence of new knowledge and development of science and technology, teaching content should be updated constantly and keep up with the pace of modernization of education[4,5].

Modernization of teaching contents includes two aspects. First, add some modern technology on the basis of original content. And secondly, break the original system and reform curricula and teaching contents from a new and higher theoretical viewpoints. Improvements of these two aspects are necessary for solid state physics but the latter is more difficult and important than the former.

After the experience and problems in teaching process are summarized, we selected the teaching contents and add necessary knowledge of solid state physics. For example, concept of Wigner-Seitz cell is added in the chapter of crystal structure and the characteristic of it is compared with primitive cells crystallographic unit cell. Meanwhile, in order to better understand Wigner-Seitz cell, concept of Brillouin zone which should be taught in chapter of energy band theory is introduced into this chapter. By doing so, the students' impressions of Brillouin zone are dept and good teaching results have been gotten.

The relation between each chapter and solid state physics with other courses are emphasized during teaching procedures. The first chapters deal with a review of chemical bonding mechanisms, crystal structures and mechanical properties of solids, which are brief but by no means superficial. The following, somewhat more detailed chapter on thermal properties of lattices includes a nice introduction to phonons. The foundations of solid state electronics are treated in the next some chapters. At the same time, according to the characteristics of teaching object, our teaching goals are not the pursuit of perfection of the theory but for the understanding of students. For example, in the chapter of nearly free electron model, we omit the mathematical derivation of perturbation theory which have been taught in the course of quantum mechanics but focus on the application of degenerate and nondegenerate theory used in solid state physics. Students not only understand what's the use of quantum mechanics but also mastered the origin of the band theory, students learning interest have been significantly improved. Advanced research of modern technology and physical which is related to teaching contents have been added under the premise of guaranteeing teaching time of the basic content.

In the chapter of magnetism of solid, we make a brief application introduction of energy band theory in magnetism theory and explains the atoms phenomenon of non-integer magnetic moments in magnetic materials student not only consolidate the learned knowledge of energy band theory but also access to the problems encountered in specific situation.

The development situation of magnetic materials in our country could be introduced to make students realize the inseparable relationship between science and applied science. According to the characteristic of civil aviation university, various lectures on special subjects of surface physics knowledge are held to make students have more profound understanding on surface engineering. The extension of the content not only broadens their outlook, but also arouses their interest and creation.

IV. REFORM OF TEACHING METHODS, CULTIVATION OF HIGH-QUALITY TALENTS

The teaching methods have been an extremely important problem for teaching and cultivation of talents[6]. Traditional teaching method in solid state physics is very simple, mainly centered on teacher known as "Inpouring Education". This model only make the students passively accept the old knowledge and could not surpass predecessors to create new knowledge. Students' creativity are limited and stifled by this model.

In recent years, with the deepening of teaching reform and practice, lots of new teaching methods have emerged in reality. The consequence of much example shows that scientific and effective teaching methods is the catalyst for fostering students' innovative consciousness and innovation ability[7]. Based on the principles of cultivating student's study interest, enhancing memory, enlightening thinking and stimulating innovation should be applied. According to

different objects and different contents, different teaching methods are used flexibly. The following teaching methods are used in our teaching process and have achieved good teaching results.

A. Heuristic Discussion Teaching

Cultivation of students' creative ability is based on innovation of thought. Innovation of thought often needs inspiration and guidance by teacher. Heuristic discussion teaching can strengthen the communication of teaching and learning, implement interaction between teacher and students,, active atmosphere in class[8].

Here is what we work: design teaching process carefully, guide the direction of thinking, broaden thinking space, inspire students to think and reason. For the reason of heuristic discussion teaching was used, students' thinking ability is cultivated and enthusiasm, initiative and creativity are mobilized. Teacher has transform from knowledge feeder and master of students to instructor of teaching, facilitator of quality development, promoters of learning and innovation.

Such as for the concept of phonon, which has been taught in the chapter of lattice vibration, the quasi-particles feature of phonon is briefly introduced in class. After class, discussion topics " similarities and differences between phonon and the electron, photon" is assigned for discussed in next class. The students had a heated discussion in discussion class because of adequate preparation.

Even in the issue "which's the real particles", arguments break out. Elusive concept becomes much more clearer through heated discussion. Students are no longer passive recipients of knowledge but subject of study.

B. Analogy and Inspiration Teaching Method

It will be beneficial for deepening the concept, strengthening memories, cultivating the ability of analysis, synthesis and comparison by seeking differences in similar concepts and realizing relation of differences in different areas of knowledge when those theories are quite abstract and difficult. Take the chapter of electron theory of metals for example, the behavior of electronic is compared with the phonon. By comparing those differences in teaching process, students get clearer physical concept of the phonon and the electron and more profound memory.

In detail, electronics are real particles, which are spinning, that obey Fermi Dirac statistics law. Those easily to be stimulated are the particles which are in near the Fermi level electronic (the electron with higher energy). For contrast, the phonon is quasi particle, no spinning that obey the Bose Einstein statistics law. The first excitation is a low frequency (namely the phonon energy is smaller) even though they have contributed on the crystal thermal conductivity rate. By such a comparison, the students have clearer impression about the physical images of phonons and electrons, and the memory is more profound.

There is an old saying can be translated that “the horse need a whip even the best”. That is same to education. People can only play his ability for 20%～30% without inspiration. But under sufficient incentive, people could playe his ability to 80 % ～ 90 % , even higher. All these demonstrate that inspiration is important means which cannot be underestimated in teaching process. Such as in the chapter of long wave approximation, the scientist HUANG Kun was emphasized during teacher process.

HUANG Kun, the proud of our country, is one of the few Chinese people cited in the textbook. His life stories and learning journey are incorporated into this book. By learning physical thoughts and derivation process of Huang equation, students could be inspired by its historical status and scientific method and be infused with his patriotism.

V. CONCLUSIONS

According to characteristics of solid state physics course, the direction of teaching reform should be listed as follows. In the aspect of teaching contents, basic theory should be combined with the advanced projects to develop students' ability of using knowledge from different courses comprehensively.

On the other hand, it is of great importance to improve students’ learning enthusiasm and initiative and train their ability of independent analysis, problem-solving and good logical thinking. Consequently, advanced teaching approaches should be applied.

These improvements thoroughly intend to change the traditional methods of teacher-centered classroom, resolve the contradiction between teaching and learning, enhance students’ professional quality, and cultivate high quality talents with scientific thinking and innovative ability.

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