The Course Reforms of Microelectronics Process Based on CDIO Personnel Talent Cultivation Model

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Abstract. The course construction and reform is the key of improving the undergraduate teaching quality and personnel talent cultivation. CDIO is a new personnel talent cultivation model in the current higher engineering education. Based on CDIO concept and the course characteristics of microelectronics process, some reform measures are explored and applied to the course construction including personnel talent cultivation ideal, curriculum structure adjustment and contents integration, course teaching methods, multimedia technology and video teaching, comprehensive experiment platform combined with college, institute and enterprise, course network platform, the undergraduate tutorial system, enterprises training base, and multiple evaluations of engineering practice ability, technology innovative ability, learning process, and students’ individual ability enhancement. These measures are applied to the course construction and have achieved obvious good results.

Introduction

High level curriculum teaching is the premise of the cultivation of high quality talents. The guideline of “Microelectronics process” course construction is closely combined with CDIO education concept.\(^1\) The course reform goal focus on improving personnel talent, in other words, cultivating the students with high-quality engineering practical talents to satisfy the needs of our national IC design industrial development, especially the students’ engineering practice application ability. Through the scientific and reasonable curriculum construction planning, we strengthen the modern and information education technology during the course teaching process, and also combine with the CDIO education mode, further optimize teaching contents, reform teaching methods and means. We also carry out scientific and reasonable evaluation of the diversified assessment to improve the teaching-learning effects of this course.

CDIO Engineering Education Concept

CDIO engineering education model is jointly founded by four universities, Massachusetts Institute of United States of America, Royal Swedish Academy of Engineering, etc. It is the latest achievements of international engineering education reform in recent years. CDIO is the abbreviation of four words: conceive, design, implement, and the operation. From the products’ research to market sale, the products as the carrier during the whole study cycle. This education and learning mode can make the students actively participate in course theory knowledge study, then actually apply them to practice application\(^1\)\(^-\)\(^3\). So far, a few of world famous universities joined the CDIO international organizations, by implementing CDIO engineering education concept have achieved obvious good results. CDIO not only inherited and developed the concept of engineering education reform in the Europe and the United States for more than 20 years. The more important is that put forward the programs of systematic ability cultivating methods and standard, including practice training plan, teaching methods, student ability assessment, learning framework, as well as 12 standards for the implementation of inspection. The requirements of the CDIO standard are directly referred to the requirements of the industrial sector, so it can excellently meet the requirements of the talents of engineering personnel in the industry.\(^4\)\(^-\)\(^6\)
Reform of Teaching and Experiment Method

The Development of Multimedia Technology of Teaching Software

The traditional PPT teaching methods and blackboard writing are not enough to illuminate the complicate chip fabrication process and the dynamic comprehend IC processing technology. Based on multimedia teaching software and flash demonstration, large numbers of 2D and 3D multimedia pictures and IC processing dynamic videos are combined together to give students a clear and intuitive understanding of the complicated IC processing and chip manufacturing. These reforms much improve the teaching effect. Figure 1 is a screen shot of a flash demo of fabricating a CMOS inverter.

![Alignment and Exposure](image1)

Figure 1. A screenshot of a flash demo of a CMOS inverter fabricating process.

Microelectronics Process Experiment and Video Teaching

“Microelectronics process” is a strong practicing course. Combined with classroom teaching course, a lot of additional experiments are set up. The experiments include: thin film preparation process, oxidation diffusion process, sol-gel doping process, packaging and testing process, etc. All of them aim to cultivate students' practical manipulative abilities and scientific analysis. The reform course also supplements the actual IC flow-process and equipment manipulating by videos teaching. Our teaching department bought the videos of Tsinghua University microelectronics IC process equipment and multimedia teaching system in 2007, and combined with the original English language video of IC process, the whole actual production process and equipment manipulating can be lively displayed in the classroom. The video of process teaching is shown in figure 2. Through the teaching reform methods mentioned above, students' learning interests were aroused and the basic theoretical knowledge given in classroom was fully comprehended.

![Video Teaching](image2)

Figure 2. The video teaching of Silicon thermal oxidation and sputtering process.
College, Institute and Enterprise Comprehensive Experiment Platform Construction

Due to the expensive IC fabrication facilities and operation, strict ultraclean environment conditions and costly maintenance operation, only a few colleges and universities such as Tsinghua University and Peking University have integrated circuit process line and test facilities. Besides, the University of Electronic Science and Technology of China (in Chengdu) also only have a part of process experiment and analysis testing apparatus. Therefore, the exploring and implement of the experiment resources sharing of the costly large-scale equipment and precision instruments, and further constructing the "comprehensive IC manufacturing technology experiment platform" between universities, institutes and enterprises through the principle of mutual benefit and paid services is a good way to solve the problem of shortage of equipment funds which some universities like us have. Meanwhile, a part of the large equipment maintenance costs can also be compensated. The open process experiment and analysis tests include thin film deposition technology by RF magnetron sputtering, MOCVD thin film deposition technology, MBE (molecular beam epitaxy), photolithography and etch technology, ion implantation and RTP rapid annealing technology, XPS, XRD and AFM analysis experiments. At the same time, the practice base established in enterprises production line can greatly cultivate students engineering practice application ability. Let the students take the theory knowledge to the real manufacturing workshop, to participate in some of the production process, microchips test and devices assembly. These experiences will improve them to understand the basic theory knowledge and the actual microelectronic enterprises, to find the problems and explore solutions to the problem. Furthermore, it is also conducive to the selection of outstanding students for the joint training and direct employment after graduation.

Course Network Platform Construction

The constructing teaching website named "microelectronics process course network platform" can be used as the supplement of the classroom teaching content. The course network platform includes lesson plans, course teaching PPT, microelectronics process videos, interlinking of related microelectronics resources, IC process development and information of current research hot spot, teaching record videos and typical case analysis, the typical question/ examples solution, all previous students' engineering practice reports, students' online discussion, special subject BBS, and other sources like online FAQ. All of the construction and maintenance of the course network platform are managed by students. Through this network platform students can review the chapters which they don’t understand well in classroom. They can also upload the learning experience and communicate with the course teachers or other students. Meanwhile through the website platform, the students' self-study ability and practical ability can be promoted greatly.

The Science and Technology Innovation Project under the Undergraduate Tutorial System

The undergraduate tutorial/advisor system is conducive to guide student’s professional learning, project development, practice training. Students participate in the teacher’s research project, and teacher being an advisor offers individual guidance for professional direction according to students’ individual interest and characters. Since 2008, our college is committed to explore and construct new cultivating mode of students’ scientific innovation and practice ability. Each year our school provides special funds for the students to carry out scientific and technological innovation projects that include students’ self-make subject, the designated scientific and technological innovation projects of our college, advisor research project, the project of related enterprises’ technical improvement. The students’ scientific innovation practices include the project selection, application form writing, and feasibility studies. Once the applied projects getting approval, the students should undergoing the project specific details design, research and development in following next 3-4 semester. Finally, the applied projects will undergo thorough checked before final acceptance through the product demonstrates, an open debate and the experts’ question and answer. Figure 3 is shown the project check-acceptance spot of "Hi- Fi speaker design and manufacture " project completed by microelectronics professional "dream & fly" team. The project leader student is responsible for the project design and development; make a comprehensive project introduction in
open debate, the whole team members answer the teacher's questions. The activities of scientific and technological innovation projects under the undergraduate advisor/tutorial system have greatly raised the students' engineering practice ability based on CDIO mode of “idea, design, implementation and operation”, and fully demonstrate the team spirit and much improve the personnel talent cultivation effects.

Figure 3. Acceptance of students’ science and technology innovation project.

Evaluation Reform of Learning Process Assessment and the Practice Ability

The examination of students’ achievement is not only the purpose of the course teaching, but also the key process of teaching reform. Its assessment methods and means are particularly important. In order to be more scientific and rational evaluation of learning results and the degree of students’ ability, we establish a wide range of the courses assessment methods and standards, no longer examine a single copy of the theory knowledge, but pay more attention to the learning process and the students individual ability enhancement, particularly, the application ability of engineering practice. The evaluation reforms reduce the proportion of final exam in the total course grade, focus on the engineering practice participation and the innovative design with more ratios, and avoid single by rote exam and the phenomenon of students’ examination with high scores but actual with low practice ability. The diversified assessments include: practice training report, a comprehensive test results, IC process design and simulation results, scientific innovation projects, special topic thesis, course homework with course attendance check, and translation report of the original English language IC process video, etc. Meanwhile it is very important in the final examination questions in weakening the single theory knowledge test and to increase the comprehensive problems, IC process design subject and the open answer question.
Summary
The implementation of CDIO personnel talent cultivation mode promotes the teaching reform of the “microelectronics process” course, which is an important professional compulsory bilingual course for the microelectronics specialty undergraduate students. To ensure the implementation of cultivating undergraduate students with engineering practice ability, we explored the training modes and reform methods include the teaching content optimization, teaching mode and teaching method reform, comprehensive experiment platform construction and enterprise practice base establishment, course network platform construction, the tutorial system and the science and technology innovation project, the ability evaluation reform, etc. Therefore, the course teaching level and effectveness, the students team spirit, the engineering practice ability and the personnel talent have been improved much.

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