Multimedia Approach to Learn Physics

BY

KIT-YUK CHUNG

A Thesis Presentation to
The Hong Kong University of Science and Technology
in Partial Fulfillment
of the Requirements for
the Degree of Master of Philosophy
in Physics

September 2002, Hong Kong
Authorization

I hereby declare that I am the sole author of the thesis.

I authorize the Hong Kong University of Science and technology to lend this thesis to other institutions or individuals for the purpose of scholarly research.

I further authorize the Hong Kong University of Science and technology to reproduce the thesis by photocopying or by other mass means, in total or in part, at the request of the institutions or individuals for the purpose of scholarly research.

KIT-YUK CHUNG
Multimedia Approach to Learn Physics

by

Kit-Yuk Chung

This is to certify that I have examined the above MPhil thesis and have found that it is complete and satisfactory in all respects, and that any and all revisions required by the thesis examination committee have been made.

Prof. Tai-Kai Ng, Supervisor

Prof. Ping Sheng, Head of Department

Department of Physics

13 September 2002
Acknowledgements

I would like to express my sincere thanks to my supervisor Prof. Tai-Kai Ng, for his plenty of valuable advice, patient guidance and supervision throughout my research. It is creditable to work with Prof. Tai-Kai Ng. I have to give many thanks to Prof. Tai-Kai Ng for his great contribution to this project. Working with Prof. Ng is happy and valuable experience.

My special thanks go to Prof. Che-Ting Chan and Dr. Kwok-Kwong Fung for helpful and their plenty of valuable advice. I have to give many of thanks to Prof. Chan and Dr. Fung for their great contribution to this project.
# TABLE OF CONTENT

Title Page i
Authorization Page ii
Signature Page iii
Acknowledgements iv
Table of Contents v

## Abstract

### Chapter 1

1.1 Traditional and Modern Media in Teaching 1

### Chapter 2

2.1 Introduction 2
2.2 Contributions of Multimedia Technology to Learning Physics 2
2.2.1 Visualization of abstract concepts and complex ideas 3
2.2.2 Learners study at their own pace 3
2.2.3 The Instruction can be more interesting 4
2.2.4 Reduced Instructional time 5
2.2.5 The quality of learning can be improved 5
2.3 Animation for teaching Physics 5

### Chapter 3

3.1 Introduction 7
3.2 Aims 7
3.3 Contents of the Animation 8
3.3.1 Introduction 8
3.3.2 Crystal lattice and Unit Cell 8
3.3.3 The Miller Indices of lattice plane 8
3.3.4 Mapping the reciprocal lattice by diffraction 9
3.4 Suggestion of Using this Animation 9

### Chapter 4

4.1 Introduction 10
4.2 Aims 10
4.3 Contents of the video 10
4.3.1 Introduction 11
Multimedia Approach to Learn Physics
by Chung Kit Yuk

Department of Physics
The Hong Kong University of Science and Technology

Abstract
Using computer multimedia technology, three educational CD-ROMs have been developed. They present information on Crystal lattice, Nano Materials and Randomness and Efficiency of Energy with the help of Macromedia Flash, Macromedia Dreamweaver, 3D studio Max, Adobe Photoshop and Adobe Premiere. Two CD-ROMs, which contain information of Crystal Lattice and Randomness and Efficiency of Energy are used to assisted in teaching Physics courses, while the other one, which contains information of Nano Materials, is used in popular science presentations. In this paper, besides introducing the content of the educational CD-ROMs, the benefits of using multimedia technologies and the future of multimedia in education will be also discussed.
CHAPTER 1

INTRODUCTION

1.1 Traditional and Modern Media in Teaching

In ancient traditional society, oral instruction was the main medium of instruction. These instructions were later recorded and edited as books which became the earliest teaching materials that assisted students in memorizing the words of instruction. As the time went by, speech and text were inadequate in explaining some abstract concepts and complex ideas. It is for this reason that pictures and other graphic forms of communication were used. Unfortunately, even well illustrated books have their limitations: they cannot produce sound and they are unable to generate animation and moving pictures. Consequently, other media have supplemented books, such as audiocassette, video tape and artifacts [12]. Nowadays, multimedia presentations created on the computer provide more sophisticated ways to support the visualization of abstract concepts and complex ideas. Videos, photos, computer animations, texts and sounds can be combined to create a richly detailed magical virtual world, in which interconnections among data can be made visually explicit [2].
CHAPTER 2
MULTIMEDIA TECHNOLOGY IN LEARNING PHYSICS

2.1 Introduction

In general, multimedia technology makes use of several media to present information. Combinations may include texts, graphics, animation, pictures, video and sound [10]. These combinations have the power to evoke emotions, change attitudes and motivate actions. Multimedia technology makes use of the power of these combinations to compel attention, to help viewers understand ideas and concepts, which are too complex for oral instruction alone. The impressions that are created by the combinations have been shown to be retained by viewers significantly longer than reading or verbal learning [9].

2.2 Contributions of multimedia technology to learning Physics

The ancient Chinese proverb: “Tell me and I forget, Show me and I remember, Involve me and I understand” still holds true in the multimedia age. Besides encompassing the oral instructions of the instructor, learners may also study Physics from scientific visualization, one of the well-known concepts in the academic community. Making use of multimedia technology to produce scientific visualization is making a definite contribution to the achievement of the
instructional goal [1].

2.2.1 Visualization of abstract concepts and complex ideas

Instructors can use verbal explanation to transmit information to learners [14]. However, some abstract concepts and complex ideas in Physics are not easily explained verbally without the assistance of text and pictures. Multimedia technology allows a level of analysis and visualization not possible with traditional film, audio or printed materials [13]. This is especially applicable to quantum mechanics and materials science. For quantum mechanics, it is a strange world for initiates and so the application of multimedia is particularly rewarding. It allows students to depict phenomena that cannot be visualized by any other means. For materials science, students are required to perform experiments in order to have a insight into the microscopic world. Without such experiments, students have to use their imagination with the assistance of pictures to learn about materials science.

2.2.2 Learners study at their own pace

Some learners may learn well by using pencil and paper or from viewing linear movies while other learners may learn much better from more
sensory media. Sensory media incorporates sights and sounds at their core and not simply as decorative facades [11]. In Hong Kong, many students are shy to ask questions or express their opinions in the classroom especially when they are confused about some basic conceptual problems. Gradually, they fall behind and hence a passive learning cycle is formed. By using multimedia technology-based learning, this passive learning will be improved [14]. Learners can choose the starting point and content of revision as required. Upon encountering an unclear section, they can review the explanations or sample exercises without hindering the pace of other learners. Moreover, learners can study at a time and place that is personally convenient. Without the limitation of time and pressure from outsiders, learners can learn more easily and relax with a self-controlled environment [14].

2.2.3 The instruction can be more interesting

A technology-based presentation tend to keep learners alert [5]. The clarity and coherence of a message, the attractiveness of moving pictures and the use of special effects can arouse curiosity [9]. Therefore, learners can study Physics not only by using text and pictures but also by using
animations or simulations.

2.2.4 Reduced Instructional Time

Most media presentations, such as videos and animations, require a short time to transmit their messages. During this short period, a vast amount of information can be communicated to and assimilated by the learner. This can lead to greater efficiency in the use of time for both the instructor and the learner during the instructional time [9].

2.2.5 The Quality of Learning Can Be Improved

When there is a detailed selection of subject matter available, multimedia technology can communicate elements of knowledge in a well-organized, specific and clearly defined manner. As a result, with appropriate effort on the part of the learner and suitable follow up activities, learning is expected to reach an acceptable level [9].

2.3 Animation for Teaching Physics

Education can benefit from computing without suffering any of the negative side effects about which critics have warned, such as erosion of human interaction and peer relations or decline in the importance of the teacher as mentor [3]. On the contrary, the advantages of using multimedia technology have been mentioned
above. In this thesis, two animations and one presentation with simulation have been done in order to provide an alternate way to learn Physics. The two animations show some basic ideas in materials science, crystal lattice and nano material, while the simulation shows the efficiency and randomness of energy.
CHAPTER 3

ANIMATION OF INTRODUCTION OF CRYSTAL LATTICE

3.1 Introduction

In the microscopic world of materials science, the applications of visualization techniques are particularly rewarding. However, most of the applications are set up in laboratories and experiments have to be done in order to have an insight on a sample. The strict organization of lectures will impose limitations on the scheduling of experiments. Therefore, they have to use their imagination combined with the printed materials to learn about materials science, such as the structures of crystal lattices. Fortunately, due to the rapid advances in information technology development, multimedia has provided an alternative way for us to learn about the microscopic world of materials science without performing experiments. In this chapter, an animation of 'Introduction of Crystal Lattice' will be introduced.

3.2 Aims

In this animation, the abstract concept of the crystal lattice is being visualized. Students can learn the structure of the crystal lattice without performing experiments or visualizing it mentally. In addition, different students learn at a different pace. Using this animation, students can learn at their own pace.
3.3 Contents of the Animation

This animation consists of four modules which use graphics, sound, as well as text to present information on: Introduction, Crystal Lattice and Unit Cell, The Miller Indices of the Lattice Plane and Mapping the Reciprocal Lattice by Diffraction. Since these four modules can be played individually, an interface was made with the help of the C++ language. This is an animation with display adjustments, i.e. user can start, stop and pause through the animation.

3.3.1 Introduction

In the first section, the contents of the animation are introduced.

3.3.2 Crystal Lattice and Unit Cell

By using sodium chloride crystal as an example, the definition of a crystal, a crystal lattice and lattice parameters are illustrated. Afterwards, the difference between a primitive cell and a unit cell are illustrated by using face-centred cubic lattice (sodium chloride crystal).

3.3.3 The Miller Indices of the Lattice Plane

This part of the animation is about the Miller Indices of the Lattice Plane. It uses a simple equation to explain the relation between the lattice plane and the corresponding Miller Indices. Utilizing the face-centred cubic
lattice, two examples of finding the Miller Indices of a plane are shown.

3.3.4 Mapping the Reciprocal Lattice by Diffraction

The purpose of having second and third sections in the animation is to arouse the memory of students in crystal structures before moving to a new subject matter. The last section is the most important part of the animation. The diffraction grating of light is used to illustrate the diffraction pattern before the discussion on the diffraction of X-ray or electrons by the crystal lattice. In the discussion of the diffraction by the crystal lattice, the animation shows how the real lattice maps to the reciprocal lattice. The animation finishes with presentation in regard to the importance of determining the reciprocal lattice.

3.4 Suggestion of Using This Animation

Normally, there are few, if any, students can fully understand the content shown in the eight minutes of animation from a single viewing. Therefore, multiple viewings are essential. Instructors should show the animation two or more times, stop at designated points, explain what can be learned from the animation and lead a discussion. This will enforce concepts and allow for students to memorize more readily the content.
CHAPTER 4

VIDEO OF NANO MATERIALS

4.1 Introduction

Technologies are constantly changing; scientists continue to make new discoveries. We can obtain the most updated information from different media, such as newspapers, television, etc. If we wanted to know more about achievements in scientific research, we would have to read the research papers. However, it is often too technical and difficult for the public to understand the contents of these papers. Multimedia provides an interesting way to introduce achievements in scientific research.

4.2 Aims

Over the past few years, the field of nanotechnology and nano materials has greatly expanded. It is not only a major talking point in science, but also to the public. The word, nano materials, is often mentioned in news articles and magazines but to the general public, this is just technical jargon. By watching this video, viewers can have a basic idea about nano materials.

4.3 Contents of the Video

This video can be divided into six small parts: Introduction, The Advantages of

4.3.1 Introduction

In this part, the development of the micrometer scale, during the eighteen century, to the present day, nanometer scale is introduced.

4.3.2 The advantages of developing nano materials

By using texts, photos and animations, three advantages of having nano-materials are shown: saving materials, saving powers and helping the development of computers. In addition, why carbon nano-tubes have some novel properties is explained.

4.3.3 Carbon Nano-Tube

There are several methods used to prepare carbon nano-tube: laser ablation, arc discharge and chemical vapor deposition. In this part, using computer graphics to introduce a new method, which used zerolite as a mold, and this method can prepare the smallest carbon nano-tube in the world.

4.3.4 The Novel Properties of the Smallest Carbon Nano-tubes
Some video clips have been used to present some of novel properties of carbon nano-tube with 0.4 nanometer as its diameter.

4.3.5 The Advantages of Using Carbon Nano Tube as Materials

In this part, many illustrations are used to present the following information: the tensile force of carbon nano-tubes is greater than the best steel, using carbon nano-tube to produce field emission display and storing lithium by carbon nano-tubes in mobile or notebook batteries to allow for a greater capacity.

4.3.6 ER (Electro Rheological) fluid

In this part, animation is used to explain what is an ER fluid and what will happened when there is an electric field. Moreover, two experiments of ER fluid, ER fluid gears and electronic anti-lock brake system, are shown.
CHAPTER 5

PRESENTATION OF EFFICIENCY AND RANDOMNESS OF ENERGY

5.1 Introduction

It is undeniable that markers, whiteboards and overhead projectors are the best partners of instructors in a classroom. It is obvious that only text and static graphics or pictures can be shown to students. It is inconvenient for instructors to renew the content on the slides or notes as this would mean a renewal of the whole or partial set of slides. However, instructional multimedia provides a convenient way to update or renew content. For example, power point is a good presentation tool that can involve video, text pictures or even simulations.

5.2 Aims

In this presentation, a simulation of billiard balls with elastic collisions is used to help the illustration of the Second Law of thermodynamics. Students can study the concepts of randomness and efficiency of energy from this presentation. And they can try this simulation even after lectures.

5.3 Content of the Presentation

In the real world, there is no perfect system, i.e. there is no perfect engine or perfect isolated system. Introducing the Second Law of Thermodynamics to
students who study other disciplines of Physics, a simulation with an explanation is
used in the class. This presentation is used to assist in the teaching of the Second
Law of Thermodynamics and is coordinated by the instructor in the class. Since
there are no audible content in the presentation, verbal explanation by the instructor
is required. Also, students can access the simulation after class and study the
physical aspects of the law. There are two modules in the presentation, computer
simulation and text.

5.3.1 Computer Simulation

There are three simulations in this presentation, they include two, four
and eight billiard balls in the system respectively. The goal of the
simulations are to hit a particular ball, which is designated by the
instructor, into the exit that is designated on the right hand side of the box.

5.3.2 Text

To introduce the second law of thermodynamics by using real life
examples. Using the presentation of the simulation of the two-billiard
balls system, a perfect engine is illustrated. After that, the four and
eight-billiard ball system should be showed and it would be more difficult
to hit a particular ball into the exit without colliding with other balls.
Hence, the concepts of randomness and efficiency of energy can be introduced.
CHAPTER 6

THE FUTURE OF MULTIMEDIA IN EDUCATION

6.1 Multimedia in Learning Physics

There is several multimedia technologies currently used in learning Physics: video tape, Compact Disc Read Only Memory (CD-ROM), simulation and World Wide Web. Video tapes are the earliest teaching materials to make use of multimedia technology. It is used to display realistic high quality pictures and to present dangerous experiments that cannot otherwise be done in a general laboratory. With the rapid development of multimedia technology, CD-ROM has replaced the video tape as both a cheaper alternative and a more convenient way to store data. Moreover, CD-ROM can be used to store computer animation, combined with video and audio, digitally and provide an interactive learning environment. However, even showing video to students is not the best way for learning. Simulation provides a good way for learners to understand the abstract concepts and complex ideas. For example, the concepts of chaos can be explained clearly by simulation. Learners can input different initial values to simulate the path of the particles and show the chaotic motions. In the past decade, a communications network called the World Wide Web (WWW) or simply the Internet emerged. One
of the uses of Internet is the delivery of educational material and the support of
education. Thus, an enormous amount of information can be found and accessed
from the Internet to facilitate students.

6.2 The Future Role of Multimedia in Teaching and Learning

In the eighties, video tape, a type of instructional media, was the main teaching tool
in a classroom. Eventually, different kinds of teaching tools appeared, such as
CD-Rom, simulation and World Wide Web. Even though video tape is no longer the
dominant teaching tool or instructional media, a combination of different teaching
tools is now commonly used.

There are many teaching tools available in the market. Users or instructors should
carefully choose the teaching tools that is suitable for them. They should avoid
using just one kind of teaching tool, but should combine different teaching tools
together.

It is difficult for us to forecast the future in a time of rapidly changing technologies.
For example no one could have predicted that the Internet and World Wide Web
would become so important. [7]. Nevertheless, some general future developments
seem likely to take place.

6.2.1 The Internet and The Web
It seems safe to predict that the Internet and the Web will continue to grow in size, popularity and influence [8]. It is obvious that instructors and learners will continue to make increasing use of them as teaching and learning aids in the future. Moreover, the increasing sophisticated multimedia on the Internet and the Web will make the educational simulations continue to be more and more similar to the real environment and events on which they are based [3].

6.2.2 **Web Course and Distance Education**

Web courses and distance education are likely to be ongoing projects in Hong Kong. Many universities will offer courses and programs online, and this trend is likely to extend downwards into secondary schools [4]. There are both advantages and disadvantages with this trend. Traditional programs may be made more convenient and more accessible as online technology is used to supplement the courses and the programs but increased online competition may have a negative effect on quality [3].
CHAPTER 7

CONCLUSION

7.1 Conclusion

In the past, oral instruction, books and pictures or graphics were the main teaching tools. As the technology evolved, the combination of sound, video, animation, text and graphics created a new media for teaching complex ideas or abstract concepts. By using multimedia technologies as our teaching tools, there are no negative contributions to education. On the contrary, many benefits can be found from using multimedia technologies in teaching and learning Physics. We have illustrated some examples with the three multimedia teaching tools that are enclosed with this paper; two animations about material science with user selective interfaces and one simulation about general Physics.

There are four small modules in the first animation, Introduction of Crystal Lattice. In this animation, the abstract concepts of crystal lattice is visualized. Students can study material science more conveniently.

Over the past few years, the field of nanotechnology and nano materials is expanding.

The second multimedia presentation targets both the academic and none academic
and shows how multimedia can bring scientific ideas and concepts to the general public.

The third presentation helps students visualize the concepts illustrated by the Second Law of Thermodynamics.

In a time of rapidly changing technologies, the future of multimedia in education is difficult to predict. However, it is safe to say that the Internet will continue to grow in size and usage. And also, more and more web courses and distance learning will be provided on the web.
Bibliography and References:


Appendix A  Scripts of Animation of Crystal Lattice

Introduction:

Do you know how to choose a unit cell in a crystal lattice? Do you still remember about the Miller Indices of the lattice planes? Do you still remember the diffraction pattern of a diffraction grating? What is the relationship between the diffraction pattern and a grating or crystal? If your answer is no for either one question, this CD Rom can help you.

In this CD Rom, there are 3 parts which are Crystal Lattice and Unit Cell, Miller Indices of Lattice Planes and Mapping the Reciprocal Lattice by Diffraction.

Now you can click one of the buttons to view the video.

Crystal Lattice and Unit Cell:

A crystal is an assembly of groups of atoms (ions or molecules) arranged regularly in space. In a NaCl crystal, the group of atoms is a Na atom (ion) and a Cl atom (ion). In the NaCl model, Na atoms are represented by the green balls while Cl atoms are presented by blue balls. Replacing the Na and Cl pair by an equivalent point, the infinite regular array of points in space defines a crystal lattice. The number of lattice points or atoms in a small crystal is a significant fraction of Avogadro’s number \( (10^{23}) \). The lattice points can brought into coincidence with one another by lattice translations. The shortest lattice translations between nearest neighbours in three non-coplanar directions are usually chosen as the lattice
parameters. The lattice parameters define a parallelepiped unit cell with 6 faces and 8 vertices. The structure of a crystal is determined when the unit cell and the positions of the atoms in the unit cell are determined. This means that we only need to study one unit cell rather than the whole crystal.

As you can see, unit cells of different shapes and sizes can be chosen in a crystal lattice. Normally, the smallest unit cell with the highest symmetry compatible with the crystal structure is chosen. When there is just one lattice point, the unit cell is termed a primitive unit cell. In the case of the NaCl crystal, a primitive cell is not favoured since it does not display the full symmetry of the crystal. The NaCl lattice is a face-centred cubic (FCC) lattice. A cubic unit cell is chosen with Na atoms at the corners and the face centers of the cube and Cl atoms at the midpoints of the edges and the center of the cube. There are four lattice points, but 8 atoms (4 Na and 4 Cl) in this unit cell.

**Miller Indices:**

Crystals are known to be anisotropic. The physical properties of a crystal is different in different directions. It is useful to describe a crystal in terms of sets of crystal planes. The crystal plane in different directions are different. Using Cartesian Coordinates, a lattice plane can be written as

\[
\frac{X}{m} + \frac{Y}{n} + \frac{Z}{p} = 1
\]
where X, Y and Z denote the coordinate of points on the plane, and m, n and p are the intercepts of the plane on the crystallographic axes x, y and z. A lattice plane is defined in terms of the reciprocal of the intercepts as follows:

\[ h = \frac{1}{m}, \quad k = \frac{1}{n}, \quad l = \frac{1}{p} \]

Lattice planes are written as a triple (hkl) in round brackets. h, k and l are known as the Miller Indices. Note (hkl) denotes an infinite set of lattice planes. A set of lattice plane is specified by its position or orientation and the spacing between adjacent planes in the set.

Do you still remember how to find the Miller Indices of a plane? Anyway, Let’s do it together. First, considering this face of the unit cell. Both of the x-intercept and z-intercept are infinity while y-intercept is 1/2. Thus,

\[ m = \infty, \quad n = \frac{1}{2}, \quad p = \infty \]

\[ \Rightarrow \quad h = 0, \quad k = 2, \quad l = 0 \]

How about this face?

\[ m = \infty, \quad n = -\frac{1}{2}, \quad p = \infty \]

\[ \Rightarrow \quad h = 0, \quad k = \frac{5}{2}, \quad l = 0 \]

Similarly, you can find the Miller indices of the other four faces.

Optional: If sets of equivalent lattice planes are related by the symmetry of the crystal system, they are called planes of a family. The indices of one plane
of the family are enclosed in braces as \{hkl\} to represent the indices of one plane of symmetrical planes. For example, the Miller indices of the cubic surface planes (100), (010) and (001) are designed as a family by the notation \{100\}.

Note that lattice points need not be in a lattice plane, they can be above (or below) the lattice plane.

**Mapping reciprocal lattice plane by diffraction:**

Before we go into the diffraction of X-ray or electron by a crystal lattice, we discuss the diffraction of light by a grating first. A crystal is a three-dimensional grating to X-ray and electrons. Consider a one dimensional grating of vertical lines. The optical transform of a set of vertical lines with spacing \(d\) is a row of horizontal spots with spacing inversely related to \(d\). Now, rotating the vertical lines into a horizontal position. We can get a vertical row of spots. What is the diffraction pattern of a two-dimensional grating of vertical and horizontal lines?

Consider the [001] projection in the unit cell on the x-y plane. As you can see, there are 9 lattice points on the x-y plane. The three x-z planes appear as three vertical lines while the y-z planes appear as horizontal lines. Hence an equivalent two-dimensional grating of vertical and horizontal lines is obtained. Let the spacing between the vertical or horizontal lines be 1. The [001] diffraction pattern obtained is
similar to that of the two-dimensional grating considered above. The spacing of the
diffraction spots is also 1.

Next, consider the diagonal planes of the [001] projection. The diffraction
pattern of the diagonal planes is similar to that of the one-dimensional grating
obtained above. As before, the spacing of the diffraction spots is related inversely
to the spacing of the grating. The real plane spacing is $\sqrt{2}$ (Why?). The
separation of adjacent diffraction spots is $\sqrt{2}$ which is larger than 1. The
diffraction pattern is a regular arrangement of diffraction spots. Each diffraction spot
denotes a set of lattice planes. These diffraction spots define another lattice. This
lattice is reciprocal to the real space lattice and is simply referred to as reciprocal
lattice.

Why the reciprocal lattice is so important? To determine the structure of a
crystal, we have to know the position of all the atoms in the unit cell. If we study the
crystal in real space, apparatus with atomic resolution is required. This can be done
with STM. But atoms in the interior remain inaccessible. But we can readily
obtain the reciprocal lattice by means of X-ray or electron diffraction, closely spaced
lattice planes will give widely separated spots so that the atomic spacing can be
determined much more accurately by diffraction. The crystal structure can then be
deduced from the diffraction pattern or reciprocal lattice.
Appendix B  Scripts of Video of Nano Materials

介紹：

開始講納米材料的特質之前，先簡(簡)介紹什麼是納米（nanometer）。納米即
是十億分之一米，是很細的意思，納米材料即是很細的材料。早於幾千年前，所謂
古文化、埃及文化、中國文化時，人類都醉心於發展大型的結構上，例如金字塔、
萬里長城等。直至經過三千多年的科學發展，尤其經過工業革命之後，尖端技術由
愈大愈好演變到愈精巧愈好。到五(簡)十八世紀，鐘錶是人類認爲最值得驕傲的科
技，當時科技已經做到毫米（mm）。現今的工業技術，最常用的是集成電路晶片，
這一種電路晶片的體積是微米級（micron），一般家庭電腦、手提電腦、手提電話
等都會用到。時至今日，科技的尺度又再縮減多一百倍或一千倍，達到最新的技術
——納米科技。

發展納米級科技的好處

之前都提過，納米即是十億分之一米，但究竟有多細呢？一個氫原子的直徑大
約是1個埃（1Å），即是零點一個納米（0.1nm），所以幾個原子排列起來，就會
是一個納米。基本上，納米是人類可以控制物料最細的尺度。

但是，為人要做的事這麼細的材料呢？原來細是有很多好處。第一，可以節省
材料，棄掉時又可以減少多廢物，例如相對於1950年的電腦，現今電腦體積可
以稱得上是小巫見大巫；第二，可以節約能源，因爲器件愈細，所需要的能源愈少；
最後是有助電腦科技的發展，而且機械愈細速度就愈快。剛有電腦時，其體積大，但儲存量小速度慢。現今的微米級技術，已可使電腦體積已可以大大縮細，而且儲存量亦更大速度更快。但如果將納米技術用於電腦發展，將一本厚書的內容儲存於細如一個針盒的地方，亦指日可待。

發展納米級科技時的發現

現今人類的科技漸趨微型化，當人類發展納米級科技時，發現原來當東西細到某一程度時，出現一些特性是較大的東西沒有的。嘗試很簡單地解釋究竟為什麼東西細到某一個程度會有不同的特性。其實，肉眼所看到的物質，表面原子同裡面原子比例差不多是零，所以一般材料的性質完全是由裡面原子的性質所決定；但是，納米材料的部份原子都是是表面，由於表面原子同裡面原子的比例有所不同，性質亦會不同。

其實這種科技仲是好新，是不能夠用「成功始於在嘗試」這一種態度去研究納米材料，需要將理論和實驗合而為一才可以造出納米材料。

納米炭管

接著要介紹的是一種納米科技的研究－－納米炭管。利用一張蜂巢形狀的石墨二維平面（Graphite sheet），將它捲起至直徑為 1 個納米，這種就是納米炭管。

但事實上，並不可以將石墨捲起成為納米炭管。製造納米炭管可以有幾種方法：雷射蒸鍍、電弧放電及化學氣相沉積（Chemical Vapour Deposition CVD），但
是這幾種方法所得到的納米炭管大小不一。如果要得到大小一樣的納米炭管，就需要納米級模具（mould），例如沸石（zeolite），沸石有好多種，其中一種有一個個一納米直徑大的窩，而每一個窩是可以好長，只要將有機物質放入去，然後燒剩炭原子和將炭原子排好，便成為納米炭管。這種方法是由科技大學物理系湯子康博士發明，如果利用這種方法所得的納米炭管直徑只得零點四納米，暫時是世界上最細的納米炭管。

科大研究出來納米炭管與其他納米炭管的分別

直徑只得零點四納米的納米炭管有一些功能是其納米炭管沒有的。第一，其他納米炭管都是黑色，而這種納米炭管是可以由完全透明到深啡色；第二，當利用激光照射時，其他納米炭管並不會發光，但這種納米炭管則會發光，可以光電兼容。第三，這種納米炭管是一種超導體（superconductor），只要當這種納米炭管達到某一個低溫時，沒有電阻，可以電流經過而無任何消耗。

利用納米炭管作材料的好處

納米材料有很特別的性能，而納米炭管相信是已家世界上做到的拉力最強的材料，但比最好的鋼絲的拉力再強二十倍。基本上，暫時都無可能是世界上再做到一種比納米炭管更大拉力的材料。

除此之外，由於納米炭管可以通電，這個會是世界上最尖的針，利用尖針放電的原理，可以造到平面顯示器。現時電視機咁大是因爲裡面的電子熒很大的原故，
但是利用納米炭管所造出来的平面顯示器，則可以好薄。

鋰是一種很活躍的金屬，但用作電池卻有非常高的儲電量，例如手提電話或手提電腦都是用鋰電池。如果將現今用作儲存鋰的炭改為用納米炭管，電池的儲電量可達高一倍，電池壽命亦因而延長好多。

**ER Fluid**

電流變液（ER fluid）是智能變流（Smart Fluid）其中一種，電流變液是一種懸浮液，這種懸浮液中的懸浮物都是電介質（dielectric），當上下都放置電極時，懸浮液會變成類似固體的物質，由於固體拉力是由電場的大小控制，電場愈大拉力愈大。實驗顯示，納米級電流變液比微米級電流變液的拉力強度大幾十倍。再落黎，介紹兩個實驗，電流變液傳動系統同埋電子減速系統。

電流變液傳動系統：比機械齒輪更精密，沒有噪音，而且更環保。在這個箱子內面放置左(音)兩個轉盤，兩個轉盤之間放了一些電流變液，當有電場通過，電流變液會由液體變成固體，兩個轉盤會連在一起並升起重量，當重量到達感應器後，會自動切斷電源，因而重量慢慢下降。新一代的電流變液傳動系統是利用納米級電流變液，比起利用微米級電流變液的舊有傳動系統，可以負荷的重量亦相對重好多。

電子減速系統：這兩個黑色的圓柱體是代表汽車的車輪，均由摩打帶動。開動摩打後再關掉，可見兩個車輪開動及停止時間相約，將左手邊的車輪加上電流變液減速系統，再次開動摩打後再關掉，可見加上電流變液減速系統的車輪較快停止。