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3D Stereo spatial phase diagram for a typical complex ternary system

Abstract

Phase diagrams serving as the fundamental guidance in materials science and engineering are of complicated structure and hard for understanding. Although they can construct as 3D geometry in software, the display is pseudo three dimensional. The 3D stereo display of a typical Class I and Class II four-phase reaction combined ternary phase diagram was realized. All of these can be displayed by the three typical ways: electronic shutter, polarization and anaglyph (for example red-cyan glasses). Especially, they can be printed out with 3D stereo effect on paper, and watched by the aid of anaglyph glasses, which makes 3D stereo book of phase diagrams come to reality. The spatial structure, i.e., the spatial relationship of wire frame, curves, surfaces and planes can be clearly and immediately perceived. The 3D stereo phase diagram is useful in teaching and research.

Keywords: 3D stereo display; phase diagram; ternary system; four phase reaction, spatial relationship

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Introduction

Phase diagrams describing phases under varying composition, temperature and pressure are considered as the road maps for metals and alloys, minerals and ceramics. They are usually of very complicated spatial geometry, hard for understanding. Wireframe phase diagram models have been always used in teaching and scientific research since 1950's.[1] As information technology appeared, computer aided drawing of phase diagrams came to be popular.[2–9] Some commercial phase diagram software were developed, such as Panda T, Thermo calc, Fact Sage, etc. However, the display of 3D phase diagram on monitor or paper is actually a faked 3D stereo display. They are 3D shapes, but they can be only watched as 2D images, 3D effects are realized by perspective view, or by rotation and slicing of the models. It is hard to tell the special relationships of curves, surfaces and solid regions of the three dimensional phase diagrams printed in books. Tamas and Pal realized 3D stereo effect of phase diagrams by anaglyph method as early as 1970.[10] But, all the figures were the combinations of only red and cyan lines and curves by hand drawing. Thus, it was impossible to realize plane shading, transparency effect, color pictures and movies. Kang et al. managed to improve the illustration of complex phase diagrams, such as wireframe phase diagrams, computer aided models and introduced 3D stereo visualization into phase diagram and modeling and simulation and published an album about simulated results of castings in which the stereo effect can be achieved by the aid of red-cyan glasses.[11–13] In this paper, with the adoption of 3D stereoscopic visualization technology, significant 3D stereo effect of a typical complex phase diagram was realized.

Construction of 3D stereo phase diagrams

Construction of 3D phase diagrams

Phase diagrams can be drawn in CAD software. For ternary systems, the bottom is the Gibbs triangle with the three components at each corner. Usually an equilateral triangle is adopted for convenience. The vertical axis is the temperature scale. For illustrative phase diagrams, they can be constructed directly according to their shape. For real systems, the locations of each curve, plane should be based on measured values or from calculated results. And the composition of a location (A%, B%, C%) should be transformed into (x, y, z) in Cartesian coordinate system.

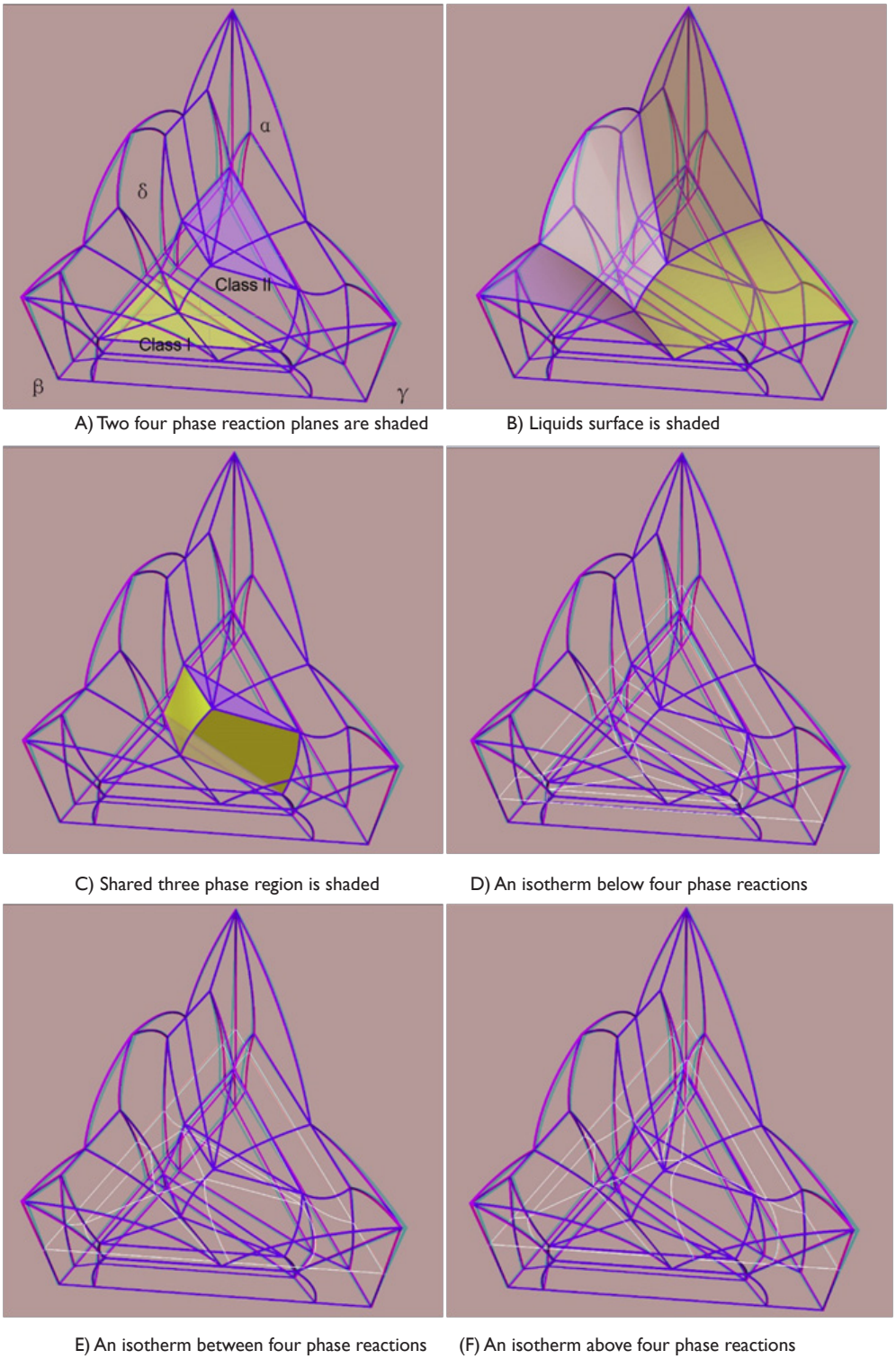
Realization of 3D stereo phase diagrams

3D stereoscopic visualization technology is mainly based on the principle of binocular parallax. Firstly, a 3D geometry should be viewed in two directions as by left and right eyes and then two images are created for left and right eyes, respectively. Secondly, stereo effect can be perceived by the observer when two images of an object simultaneously received by two eyes are transmitted to brain. The two images need to be projected to left and right eyes at the same time, respectively. There are mainly three ways to project and separate two conjugate images corresponding to left and right eyes in front of eyes by using active electronic shutter, polarization or color anaglyph 3D systems (projectors and glasses). For example, red-cyan glasses can provide red-filtrated image and the cyan-filtrated image for left and right eye, respectively. And their combination generates a 3D stereo image. With the aid of specialized software, the conjugate views can be saved; with special hardware: 3D stereo graphic card, monitor and glasses, the 3D stereo visualization can be realized.

Application into a ternary phase diagram

A class I and II combined ternary phase diagram was constructed by Software Solid works. Class I is a reaction of eutectic four phase transformation and Class II is one of eutectic-peri tactic in ternary system.[1] Wire frame and shaded surfaces can be illustrated. Here, these 3D phase diagram files were displayed by Insight. For any view or rotation, zooming, sectioning process, views can be disposed into two separated images or movies. Then, they can be used for any type of 3D stereo display by the aid of special hardware and software. Here, a series of 3D stereo images of a class I and II combined ternary phase diagram were shown in Figure 1. The 3D stereo effect can be observed by wearing red-cyan glasses (red glass for left eye and cyan glass for right one). It is easy to tell the spatial relationship of the curves, surfaces and planes which are at different depths, some popping out of paper, while others extending behind paper. This greatly helps the understanding of phase diagrams. The overlapping of the two four-phase planes can be clearly felt. They share a three phase region, as shown in Figure 1C. Isotherms can be given at any temperature. Here, three ones, below, between and above the two four phase reactions

were given respectively. With the help of the isotherms, these two four phase reactions can be easily understood. Meanwhile, isopleths can be drawn as well. And a certain alloy can be selected by corresponding to a certain location in the bottom triangle (Gibbs triangle). Its solidification paths of each phase, liquid, solids can be shown on the surfaces. And their fractions can be calculated based on level rule applied on tie lines or tie triangles.



A) Two four phase reaction planes are shaded

B) Liquids surface is shaded

C) Shared three phase region is shaded

D) An isotherm below four phase reactions

E) An isotherm between four phase reactions

(F) An isotherm above four phase reactions

Figure 1 3D stereo images of a class I and II combined ternary phase diagram (by red-cyan glasses).

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Prospection

This 3D stereo phase diagram has been adopted in teaching and presentations, achieving surprising results. They can be illustrated on monitors and screens of computers, TVs and even cell phones by the aid of specific glasses related to 3D stereo display methods. Especially for the anaglyph method, it is very convenient for presenting numerically simulated results in presentation, just with ordinary computer, projector and anaglyph glasses (such as red-cyan). Printed anaglyph 3D stereo images such as books and posters provide a great potential for the 3D stereo display in printing sector. It is necessary to develop a 3D stereo phase diagram database for teaching and research in near future.

Conclusion

A typical Class I and Class II four-phase reaction combined ternary phase diagram was constructed. Wire frame structure, shade surfaces, isotherms and isopleths can be performed on the phase diagram. Its 3D stereo display was realized by the three typical display ways, electronic shutter, polarization and anaglyph (for example red-cyan glasses). The spatial relationships of curves, lines, surfaces and planes can be perceived directly and clearly with great spatial depth across the screen or paper. Especially, the images can be printed out on paper, with 3D stereo effect as being watched by the aid of anaglyph glasses. There will be of great potential for future 3D stereo book publishing. The 3D stereo phase diagram is useful in both teaching and research.

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Conflicts of interest

Author declares that there is no conflicts of interest.

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