SCANNING PROBE MICROSCOPE HAVING CANTILEVER AND DETECTING SAMPLE CHARACTERISTICS BY MEANS OF REFLECTED SAMPLE EXAMINATION LIGHT

CROSS-REFERENCE TO THE RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 672,857, filed on Mar. 20, 1991, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a scanning probe microscope for measuring information of the surface of a sample scanning the surface of said sample with a probe as the latter is brought close to said surface, and in particular to a scanning probe microscope which is capable of obtaining different information on the surface of the same sample simultaneously.

2. Description of the Related Art

A scanning tunneling microscope (hereinafter called STM device), atomic force microscope (hereinafter called AFM device) and the like have recently been developed as an apparatus that can observe the very small configuration on the surface of a sample at an atomic level, so that these apparatuses may be used in various studies or in research.

The STM device is used, as disclosed in U.S. Pat. No. 4,343,993, to measure the configuration of surface of a sample in the resolution on an atomic level; this particular measurement process basically utilizes a tunnel current I which depends on the distance S between the probe and sample and a tunnel barrier height ($I=\exp(-\phi^{\frac{1}{2}}S)$) as the probe is placed near the sample of a conductive material by a distance of several nm, which process involves measurement of a control voltage with which the positional relation of the probe and the sample is controlled so as to render constant the tunnel current I as the probe is scanned.

The AFM device is disclosed in U.S. Pat. No. 4,724,318 (Japanese Unexamined Patent Application 62-130302), in which in contrast with said STM device, measurement can be made, independent of the electric conductivity of a sample used, in the resolution on an atomic level by detecting in view of the amount of deflection (the amount of displacement of a probe) of a cantilever (fulcrum) to which the probe is attached a very small force called the interatomic force (repulsive force, van der Waals force, covalent bond force) which has been produced between atoms in the tip of the probe and in the sample surface and measuring a control voltage with which the positional relation between the probe and sample is controlled so as to render the force constant as the probe is being scanned, whereby the configuration of surface of the sample and a distribution image of mutual action can be measured in the resolution on an atomic level. In this connection, the interatomic force can be represented by a Lennard-Jones potential having attraction and repulsive force areas, as shown in FIG. **10**, between the atoms in the top of the probe and in the sample surface.

With said STM device, the distance between the probe and sample, the local charge state density of the sample, and the local potential of the sample are reflected on a tunnel current to be detected. That is, normal STM images include information of microscopic surface roughness of the sample, information of the local charge density of states and information of local potential distribution in the sample surface. In this connection, there have been recently developed the scanning tunneling spectroscopy (hereinafter referred to as STS) and scanning tunneling potentiometry (herein after referred to as STP). In STS, a three-dimensional image (STS image) is obtained by steps of separating information of the surface roughness of the sample and information of electronic physical properties in the sample surface from tunnel currents, and extracting information of the electronic state of the sample surface. In STP, a three-dimensional image (STP image) is obtained by extracting information of potential distribution in the sample surface from tunnel current flows. The applicants of this application have already filed U.S. patent application Ser. No. 07/585,880 (EPC patent application No. 90118507.4) directed to an apparatus which enables simultaneous obtainment of STS and STP images.

Of late, special attention is devoted to more strict study of the surface physical properties based on measurement of physical information about the sample surfaces.

P. J. Bryant has discussed a system for performing simultaneous measurement of STM and AFM images in the articles, in pages 871 to 875, in the Journal of Microscopy Vol. 152, Pt 3, Dec. 1988.

FIG. **9** shows a measurement system **50** as described in this article. The system has a flexible and resilient cantilever **52** and a metallic probe **53** which are disposed on the lower side of a triaxial piezoelectric drive **51** which can drive in three XYZ directions, with the free end of the probe being positioned in the vicinity of the rear side of the cantilever **50**. The free end of the cantilever **52** is formed with an acute tip **54**, which is positioned near the surface of a specimen **55**. An STM bias applying means **56** and an AFM bias applying means **57** are provided in such a manner that an STM bias voltage V_S is applied between the cantilever **52** and the specimen **55** and an AFM bias voltage V_A will be applied between the cantilever **52** and the metallic probe **53**. Such impressions of the STM bias voltage V_S and AFM bias voltage V_A give rise to tunnel current flows between the cantilever **52** and specimen **55**, and the cantilever **52** and metallic probe **53** respectively. Namely, an electric current i_{AS} flows in the cantilever **52**, which is resulting from the addition of a current i_S flowing between the cantilever **52** and the specimen **55**, and a current i_A flowing between the cantilever **52** and the metallic probe **53**. The current i_{AS} is fed to a control circuit **58** and a computer **59**. In an attempt to keep this current i_{AS} constant, i.e. to keep constant a force acting between the cantilever **52** and the specimen **55**, a feedback voltage is applied to the Z-direction piezoelectric member of the triaxial piezoelectric drive **51**. Under this condition, by recording a feedback voltage used when the probe **53** and the cantilever **52** are scanned in the XY-directions against the specimen **55** simultaneously, AFM images (roughness images) of the specimen surface are measured in a moment of a force acting between the cantilever **52** and the specimen **55** being rendered constant, and which images are displayed on an AFM image display means **60**.

On the other hand, the current i_{AS} fed to the computer **59** is processed by the computer **59** to obtain a current i_S and consequential recording of this current is