Techniques to uniquely identify Diamonds

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<u>Abstract:</u> This invention pertains to uniquely identifying diamonds. Diamonds are very expensive and large carat diamonds are utilized for several industrial applications. Small size diamonds are frequently used for jewelry. Because of small weight and size of high priced diamonds they are vulnerable to hazards of steal and disappearance from owners and public places such as museums. The method described in this invention solidly proves ownership of diamonds and can not be easily replicated. The method is unique in the sense that another diamond can not be reproduced with the same specification. The novel idea is to employ high power focused beam of LASER to hard code critical parameters of diamonds (Index of refraction), angle of planes of cut diamonds and other requested information from owner for special customers. LASER beams created from solid state technology can make markings up to few tenths of micron in width to tens of microns. The diamonds encrypted with this method and sharp LASERS can only be observed under high magnification electron microscopes. The signature written could be placed on diamond at predetermined location known and can not be altered at a later time.

<u>Background:</u> It is well known that diamonds are very expensive. Therefore needs to be protected. Also, large diamonds are duplicated to exchange an imitation one for a real for obvious reasons. State of art techniques to verify diamonds at present time are not adequate. The current techniques require inspection of diamonds by persons who are experts in Jewelry business. This invention describes a technique of identifying diamonds so that owner with ordinary knowledge of jewelry can protect the identity of diamonds and jewelry owned by them. Our proposed method is simple, accurate and very reliable. Further identified diamond using this method will provide permanent recognition of the diamond from other similar species. At the beginning the following parameters of diamond piece under consideration are measured. Specifically index of refraction, angles of planes of diamonds from apex, size of diamond carat, number of planes or faces on diamond and etc. Then a computed signature is generated. The signature is imprinted on the diamond at a specific coordinate distance from apex.

<u>Summary:</u> As explained above diamonds are subject to stealing because they are precious. To prevent stealing and subsequent sell it is suggested that identifying symbols be scripted at a precise location on diamonds. This scripting should be performed as soon as a rough cut diamonds gains a high value when it is polished. Also, a standard should be established about where the scripting should be done. Any unscripted product should be prevented from market to fetch high price. The script is performed using an industrial laser beam. Laser beam energy is known to have an excellent control over the depth of the script, precise control over area or region of script with pin point accuracy to tenth of a micron. The tiny size of script characters may be as small as few tens of microns. The scripted information can only be seen by inspecting diamond under high magnification microscope. Because the script on diamonds consists of computer generated signature based on parameters such as index of refraction, number of planes or faces in the diamond, angle of planes cut and other parameters suggested by owner it is unique to a diamond. A duplicate diamond will not have the signature and physical measured parameters of identical value. If measured value of parameters for a piece under inspection are the same as known values of original diamond than it will not be a fake diamond. To prevent subsequent removal of LASER script two symbols on more than one face of diamonds are encrypted. The details are discussed later.

<u>Brief description of drawings</u>: In figure 1 a block diagram for inscription on diamond utilizing a LASER is displayed. Two types of measurements are done before a signature is in scripted on a polished and finished diamond. First refractive index of the diamond material is measured using an interferometer as indicated in Figure 2. Refractive index of diamonds is distinctively high than any other material. Its typical value is

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2.417. Majority of other solid materials such as glass and quartz have index of refraction in range of 1-1.5. Next angles of polished surface planes with reference to XY, YZ and XZ planes are measured. The sum of angles of planes and number of planes from apex of diamond is unique to specific diamond shape and size. Next a signature is in scripted on the diamond with parameters measured using an industrial LASER. In Figure 3 phenomenon of total internal reflection is explained to measure refractive index. In figure 4 refraction of light waves through rose diamond are displayed.

Detailed description of embodiment: A common apparatus to measure refractive index (RI) is known as refractometer. Refractometer comes in different varieties for different measurement range and prices. Price range varies from $250-$500 depending on resolution and accuracy of measurement. A measurement setup to measure refractive index of a diamond is shown in figure 2. Refractometer measures refractive index by causing angle of incident beam correspond to critical angle that results in total internal reflection. When light passes through a medium of high RI into a medium of lower RI, the incident angle of light waves becomes important factor. If the incident angle exceeds a specific value, it will reach to a point where the light ray is reflected back into medium with high refractive index. This phenomenon where reflection occurs instead of refraction is also known as total internal reflection. In figure 2 an instance of total internal reflection for light ray is depicted for water and air interface. At critical angle of incidence Sin C = N1/N2

Because there is a lot of difference in refractive index of diamond and other material it is very easy to recognize a fake or artificial diamond from a real diamond based on this measurement alone. To record information about the shape and size of diamond geometrical shape of diamond is characterized using reflectometer. Angles of faces of diamonds are measured by collimation of a light ray parallel to axis X, Y and Z reference planes. The reflected image of light facilitates face plane angle measurement. Then a serial number is encrypted for specified dealer. The physical parameters size in carats, number of planes or faces, angle of planes and refractive index for each precious diamonds is stored on a computer at the dealership along with serial number. A signature is generated from physically measured parameters and encrypted using LASER. The depth of encryption is adjusted such that the angle changes occur due to removal of encryption can be measured with nominal accuracy. When an illegitimate owner would temper and erase the encryption, he will change the angle of the plane. If he will bring the diamond for reselling encryption will be missing and angles will be different. By law diamond without serial number and dealership logo encryption should not fetch good value. This should defeat purpose of stealing.

To prevent stealing of rough diamonds by miners, they should be screened by X-rays when they finish their work day. In Figure 4 refraction of a light ray through a Rose diamond is displayed

What is claimed?

1. A method of creating unique signature using predefined computation for a diamond based on measured parameters refractive index from material of diamond, angle of planes of diamonds from apex with respect to axial reference planes XY, YZ and XZ. Keeping record of physical parameters and serial number information on a computer data base.
2. Creating an impression of the signature or imprint on surface plane of diamond with a low power industrial control LASER. Imprint dealership logo and serial number on one of the faces other than signature face of diamond.
3. The signature is located at regulated location on diamond. The depth of imprint and size (area) should not exceed predetermined dimension. The depth is restricted to few tenths of (few thousand angstroms, 1 A^0 = 0.1 nano meters) a micron and area is restricted to few (50.0) square microns. The depth of encryption is selected such that the angle changes occur due to removal of encryption by tempering surface of diamond

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(polishing off) can be measured with nominal accuracy.

4. To further protect, the signature encryption may consist of direct signature as well as bit streams of ones and zeroes for the signature computed using physical parameters.
5. To prevent stealing of rough diamonds, serial number may be encrypted immediately after a diamond is found and it is encrypted after it is polished again.

Advantages of novel invention:

1. The techniques prevent stealing of diamonds as the thief can be caught with small difficulty.
2. The method and the system allow identifying fake diamonds from real diamonds which were obtained unlawfully.
3. The two step process of applying serial number provides complete protection against theft.
4. It provides a systematic approach for tracking of diamonds availability, source and market.

Important consideration for measurements and interesting facts:

1. Refractive index of diamonds at STP conditions is 2.417.
2. Diamonds are single refraction stones. Multi refraction stones are known as Pleochronic which reflects different colors. Different colors depend on direction of orientation.
3. The index of refraction varies from 2.387-2.396 for temperature range of 0 degrees Kelvin to 900 degrees Kelvin.
4. Dispersion is variation of refraction among visible spectrum of light of differing wavelengths. For diamond it is 0.044.
5. 4C of diamonds: Cut, Color, Clarity and Carat (Weight) 50 carats = 10 grams and 142 carats = 1 ounce.
6. Several recording instrument to measure refractive index of diamonds which are inexpensive compared to price of diamonds are available.

   a. Microscopes　　b. Refractometer
   c Interferometer　　d. Ellipsometer

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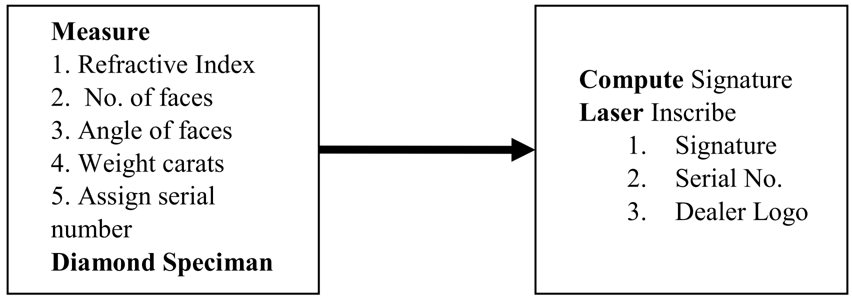
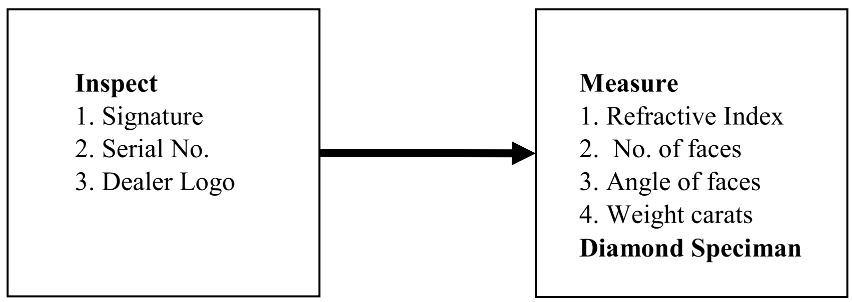


a. After polish add scripting on diamond at manufacturing



b. **When a dealer receives diamond for evaluation**.

Figure 1. Steps for inscripting daimond at manufacture and inspection process during evaluation.

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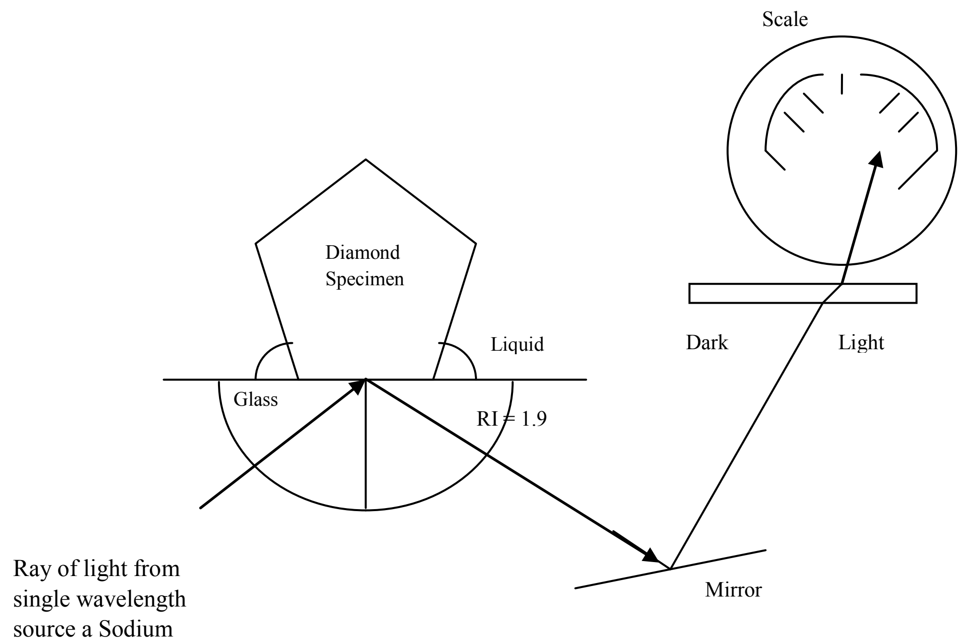

Figure 2. Refractive Index measurement using refractometer

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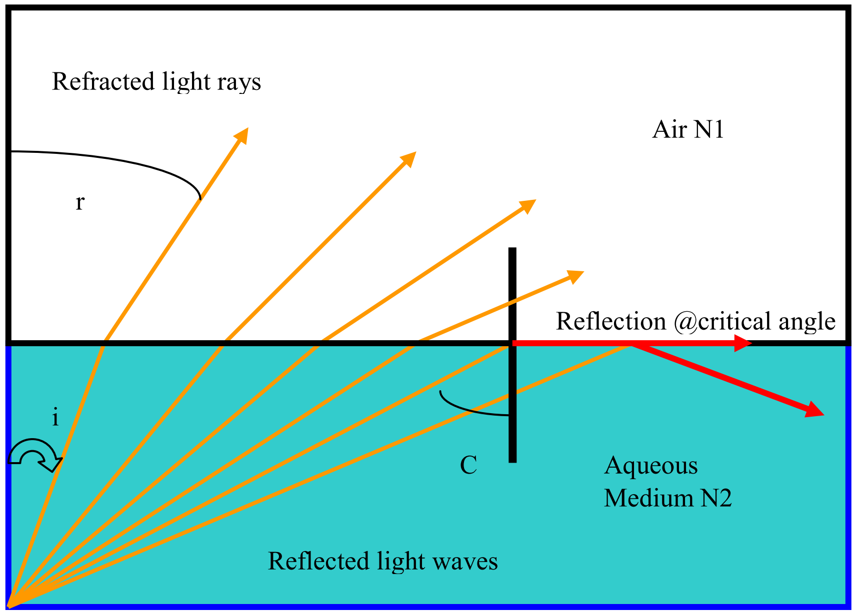

Figure 3 Refraction of light wave at water and air interface.

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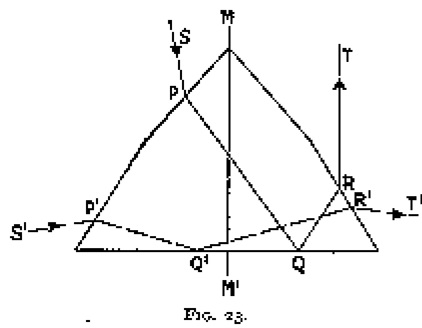

Figure 4. Refraction of a light ray in a Rose diamond.*

*Courtesy of a Study of the Reflection and Refraction of Light in a Diamond
by Marcel Tolkowsky, B.Sc., A.C.G.I.

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