RUBY STONE CLARITY INSPECTION SYSTEM USING CHARGE-COUPLED DEVICE (CCD) LINEAR SENSOR

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AUTHOR DECLARATION

I hereby declare that the work in thesis is my own unless specified and duly acknowledged by quotation.

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ABSTRAK

Delima adalah permata yang paling dicari kerana kecemerlangan cahaya, kekerasan dan nilainya yang tinggi. Delima memerlukan teknik yang rumit untuk menentukan keasliannya kerana kekurangan teknik analisis kuantitatif. Salah satu kriteria penting dalam menganalisis delima adalah kejelasan. Penyelidikan ini bertujuan untuk membangunkan sistem pemeriksaan menggunakan penderia linear CCD (Charge-Coupled Device) untuk menentukan kejelasan batu delima. Sistem penderia linear CCD dibangunkan untuk memeriksa kejelasan delima. Beberapa eksperimen dijalankan menggunakan sistem linear CCD untuk mengesahkan keupayaan penderia linear CCD dalam memeriksa kejelasan delima. Purata nilai voltan CCD dalam keadaan laser 'ON' apabila delima sintetik berada dalam sistem menunjukkan nilai yang lebih tinggi berbanding apabila tiada delima dalam sistem dengan nilai masing-masing 1.7918 V dan 1.5835 V. Apabila delima asli diletakkan dalam sistem linear CCD dalam keadaan laser 'ON', keluaran voltan CCD ialah 1.9771 V. Data keluaran voltan CCD disahkan menggunakan analisis statistik dan pemodelan matematik terbalik. Pemodelan matematik terbalik membuktikan bahawa sistem sensor linear CCD adalah sistem yang berkesan dan boleh dipercayai dalam memeriksa kejelasan delima. Hasilnya menunjukkan nilai indeks biasan delima asli dan sintetik yang hampir serupa dengan indeks biasan sebenar dengan ketepatan 98.87% dan 94.33%. Secara keseluruhannya, dapat disimpulkan bahawa sistem linear CCD ini menyediakan teknik kuantitatif, tepat dan boleh dipercayai dengan ketepatan purata 96.90%.

ABSTRACT

Rubies are the most sought-after gems owing to their brilliance, hardness, and high-value. They require a complicated technique for determining their originality due to the lack of quantitative analysis. One of the important criteria in analyzing the rubies is the clarity. This research aims to develop an inspection system using a CCD (Charge-Coupled Device) linear sensor for determining the clarity of ruby stones. A CCD linear sensor system is developed to inspect the clarity of rubies. Several experiments are conducted using the CCD linear system to validate the capability of the CCD linear sensor in inspecting the clarity of rubies. The mean CCD voltage output in the laser ON condition when synthetic ruby is in the system shows a higher value compared to when there is no ruby in the system with 1.7918 V and 1.5835 V respectively. When natural ruby is placed in the CCD linear system in the laser ON condition, the CCD voltage output is 1.9771 V. The CCD voltage output data is validated using the statistical analysis and the reverse mathematical modelling. The reverse mathematical modelling proves that the CCD linear sensor system is an effective and reliable system in inspecting the clarity of rubies. The result shows almost similar refractive index values of natural and synthetic rubies to their actual refractive index with 98.87% and 94.33% accuracy respectively. Overall, it can be concluded that this CCD linear system provides a quantitative, accurate and reliable technique with average accuracy of 96.90%.

الياقوت هو أكثر الأحجار رواجًا بسبب تألقها وصلابتها وقيمتها العالية. إنها تتطلب تقنية معقدة لتحديد أصالتها بسبب نقص التحليل الكمي. أحد المعايير المهمة في تحليل الياقوت هو الوضوح. يهدف هذا البحث إلى تطوير نظام فحص باستخدام جهاز استشعار خطي CCD (جهاز الشحن المزدوج) لتحديد درجة نقاء أحجار الياقوت. تم تطوير نظام استشعار خطي CCD لفحص نقاء الياقوت. تم إجراء العديد من التجارب باستخدام نظام CCD الخطي للتحقق من قدرة المستشعر الخطي CCD في فحص نقاء الياقوت. يُظهر ناتج جهد CCD المتوسط في حالة تشغيل الليزر عندما يكون الياقوت الاصطناعي في النظام قيمة أعلى مقارنةً عندما لا يكون هناك روبي في النظام مع 1.7918 فولت و 1.5835 فولت على التوالي. عند وضع الياقوت الطبيعي في نظام CCD الخطي في حالة تشغيل الليزر ، يكون خرج جهد CCD هو 1.9771 فولت. يتم التحقق من صحة بيانات خرج جهد CCD باستخدام التحليل الإحصائي والنمذجة الرياضية العكسية. تثبت النمذجة الرياضية العكسية أن نظام الاستشعار الخطي CCD هو نظام فعال وموثوق في فحص نقاء الياقوت. أظهرت النتيجة قيم معامل انكسار مماثلة تقريبًا للياقوت الطبيعي والاصطناعي مع معامل الانكسار الفعلي بدقة 98.87٪ و 94.33٪ على التوالي. بشكل عام ، يمكن استنتاج أن هذا النظام الخطي CCD يوفر تقنية كمية ودقيقة وموثوقة بمتوسط دقة 96.90٪.

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LIST OF ABBREVIATION

ppm	parts per million
ppb	parts per billion
wt%	weight percent
ct	carat
cps	centipoise
arb. units	arbitrary units