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Fast process detection of the chemical elements

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Anotace:
Tato práce popisuje rychlé mapování materiálového složení vzorku prostřednictvím zařízení Sci-Trace. Použitá metoda se nazývá LIBS (Laserová spektroskopie) a používá se pro detekci chemických prvků obsažených v materiálu. V práci se popsána metoda rychlého mapování, která je implementována v programu LabView. Program je uživatelsky napsán pro snadné ovládání celého zařízení. Výhody i nevýhody obou implementovaných metod v programu jsou popsány v práci.

Abstract:
This paper describes a Fast mapping of the material composition via Sci-Trace devices. The measurement method is used LIBS (Laser Induced Breakdown Spectroscopy) for detection of the chemical elements. The method of fast mapping is implemented in the program LabView. In the paper is only mentioned the diagram of the process measurement implemented in LabView. The same program controls the whole electronic part of the devices. This paper compares two methods for data collection. Both methods are compared and described their advantages and disadvantages.

INTRODUCTION

The LIBS technology (Laser Induced Breakdown Spectroscopy) is the method of detection element composition of materials. The LIBS [1][2] is the semi-destructive method. It means that the small per cent of the material is evaporated from the surface of the sample. Size of the evaporated material is a few micrometre. In case of the compare of this method with an electron microscope is the LIBS faster. The frequency of measurement at one point it can be from 1 Hz to 1kHz. It depends on the readout rate of the spectrometer camera. To evaporate the material from the sample is used the pulse laser. The pulse energy of Laser is around tens of units of millijoules. This energy is concentrated to small width pulse of the laser around one's units of nanoseconds or less.
Even though this method is very fast, the setting all apparatus is lengthy. For example, If the researcher wants a map of material, he must set the motors for the specific position. After the motors are on the position, the shutter must be closed. The shutter is the protection of the preview camera. If some of the steps are skipped or fail to act, some of the apparatus can be damaged. In eventual the automatization of the process is the automatization of the measurement is not only for save time and increase the repetition of measurement, but also for the protection of the apparatus. As the control part of the motors is used the six axes, Trinamic driver. The setup can be automatization by used the LabView program. [3]

METHODS

The process of measurement one point on the sample is represented in the diagram (**Figure 1**). The problem is for every single of the apparatus is needed to set the parameters in separated programs.

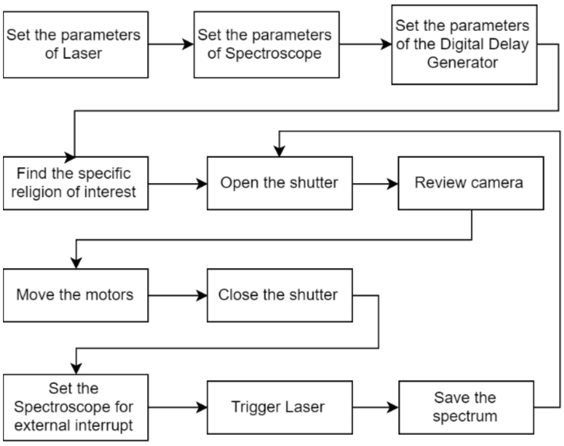

Figure 1: Diagram of process measurement.

The diagram shows the process of basic measurement by LIBS technology. First is needed to set the input parameters for Laser, Spectrometer and DDG (Digital Delay Generator). After that, it is needed to open the shutter for the show the image from the review camera. The next step is to select of ROI (Region of Interest). If the ROI is selected, the motors are moved to a specific position. The shutter is closed for the protection of the review camera. The laser shoots on the sample and the data are collected from the spectrometer. The loop cycle is implemented for automatization of collection several spectrums on several spots. The control of all apparatus is implemented into one program for the user interface.
This method is designed for a specific ROI. Even this process saves the time than the manually setting of all parameters, still, the process for the measurement chemical elements is much faster. For the layout of the chemical elements in the material is needed the collect

the data at the same spacing between the spots. In this method for layout of the chemical elements in material is better to not stopping by motor on every spot ROI but move from the start position in one axis to end position. For example, On the **figure 2** is show the first and the second method (layout of the chemical elements) of the measurement.

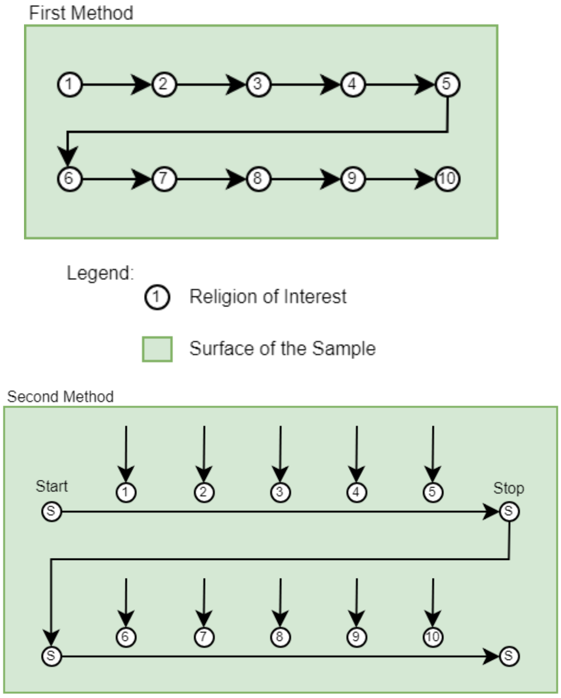

Figure 2: Methods of the process measurement.

On the left, it can see the first method. After the motor moved to the first ROI position, the laser beam is shot on the sample. In the spectrometer is saved the spectrum of the first spot. After that, the motor moves to the next position and repeats the steps. The problem is the motor has a mechanical limit of velocity and acceleration. If the spacing between the spots is low, the time to reach the next spot is similar to bigger spacing between the spots. It is caused by the limits of acceleration and deceleration of motors.

CALCULATIONS

The changes at the manipulator Sci-Trace are problematical because of the interaction chamber. The chamber is constructed for high vacuum and the mechanical parameters of the motors are not simple changeable. Because of that, the parameters of the one axis are constant. The maximum acceleration is 25 revolutions per second square. The velocity is 6.6 revolution per second. The revolution per step is 200. The microsteps in one step are 64. The thread pitch of axis is 0.5 millimetre per step. The acceleration and deceleration are 12,5 millimetres per second squared. The velocity is 3,3 millimetres per second. The time to reach the maximum velocity is around 264 milliseconds. The deceleration must be calculated too. The distance after to reach the maximum velocity and after that to stop is 6,6 millimetres.

The following conditions for calculating are the 30 micrometres spacing between the spots and 1000 of the spots. The minimum time to get data from the spectrometer is neglected.

In the first method, we need to calculate with the half spacing between the spots, because of the stopping at every position.

$$t = \sqrt{\frac{s/2}{a_{acceleration}}} + \sqrt{\frac{s/2}{a_{deceleration}}} = \\ = \sqrt{\frac{0{,}015}{12{,}5}} + \sqrt{\frac{0{,}015}{12{,}5}} \cong 0{,}070\ s \qquad (1)$$

The time to reach from one to another spot is around 70 ms via calculated acceleration and deceleration (1). The frequency of moving between the spots is around 14 Hz. The total time of the measurement is 70 seconds. The distance between the start and stopped the motor is 30 mm.

In the second method, we have the same condition. The time to reach the maximum velocity is 264 milliseconds, so the start position is a shift on 0,87 millimetres before the first spot. With the shift of the start position, we can guarantee the same size of the spacing between the spots. The Trinamic driver can trigger general digital output pin with the defined position. At every set positions, the output pulse is sent for triggering the digital delay generator. The DDG subsequently triggering the Laser and the Spectrometer. Because of that the motor does not stop and the time to reach next measurements spot is not depended on the two times square root of the spacing between the two spots divided acceleration of the motor, but on the spacing between the two spots divided acceleration of the motor.

$$t = \frac{s}{v} = \frac{0{,}03}{3{,}3} = 0{,}009\ s \qquad (2)$$

The calculated time between the spots is 9 ms (2). The frequency of the moving between the spots is around 111 Hz. The time between the first and last spot is 9 seconds, but we must add the time to reaching the maximum velocity. The total time of the 1000 spots is around 9,6 second. The distance between the start and stop of the motor is 31,74 mm.

DEVELOPMENT & TESTING

The Trinamic driver has memory for storing TMCL application. It can be used for developing standalone applications. The program has access to the internal EEPROM memory. The internal program can start via one command. The program is written for the waiting at logic 1 at specific general input for starting the internal loop.

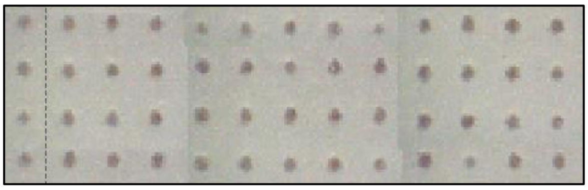

Figure 3: The test of the fast mapping with the pulse laser.

Into the EEPROM memory is written the parametric data with starting position, end position and the shifted position of the first spot. In the loop, the internal variable is compared with the current position. The internal variable is the shifted position plus the spacing between the spot and multiplies the current spot. If the current position is the same, the pulse is sent to the specific general output. The internal variable is set to the next spot. All the internal variables and numbers of the position motor are in microsteps. The real test of fast mapping is shown in the figure (**Figure 3**). The method of the non-stopping of the motors can be implemented not only for raw data collection, but it can be used for speed up the autofocusing via preview camera. With using the edge detection can be discovered the most sharpness image from the review camera.

CONCLUSION

This paper deals with the improvement of the collection of the data in the Laser Induced Breakdown Spectroscopy. The data collection is time-consuming, so make the collection fast as possible is for scientist helpful. The first method with stopping the motor at every position is only a software implementation of the method without interference into the hardware connection. It is easy for implemented, but the problem is the time to collect data.

The first method to compare the second method is suitable for collection more than one spectrum of the data at one spot (Multi-shot). The other way, the second method is much faster with the data collected at one spectrum of the data at the one spot.

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