CO Dissociation on Ruthenium Steps

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Introduction

CO dissociation is considered an important step in methanation as well as in the Fischer-Tropsch process. Hence CO dissociation over a transition metal has been studied in great detail [1,2]. CO dissociation on nickel is known to be structure sensitive since the barrier on steps are significantly lower than on terraces [3].
The aim of this research project is to examine the carbon monoxide dissociation on a ruthenium single crystal with a well defined number of steps.

Materials and Methods

The experiments are carried out in a UHV chamber equipped with a high pressure cell. The sample is a Ru(0 1 54) single crystal, it has a step density of 4%. After a thorough cleaning procedure, a CO Temperature Programmed Desorption (TPD) is made to check that the crystal is clean. Then CO is dosed at a temperature of 550 K and a pressure of $1 \cdot 10^{-5}$ torr. Now a second CO-TPD is made. Finally oxygen is let into the chamber at a pressure of $1.6 \cdot 10^{-6}$ torr and the amount of CO desorbing is measured, from this signal the carbon coverage can be calculated. The amount of steps is determined from the CO-TPD, since the area of the desorption peak in the 520 K to 600 K range is CO desorbing from the steps.

Results and Discussion

The step fraction of the CO-TPD depends on the CO dose as seen in figure 1. At high doses the amount of steps decreases, this is due to carbon blocking the steps. However at low doses the amount of steps increases, this could be due to CO_2 forming from residual oxygen or CO induced surface roughening.
In figure 2 the amount of carbon on the surface is shown as a function of dose. The amount of carbon is increasing with dose. At a dose around $4 \cdot 10^4$L the curve levels off. At this point the carbon blocks most of the steps according to figure 1.
We find a correlation between the amount of steps and the amount of carbon on the surface, CO dissociates on the step and this results in carbon blocking the ruthenium steps.

Significance

The insight gained from this model study could improve future catalyst design.

References

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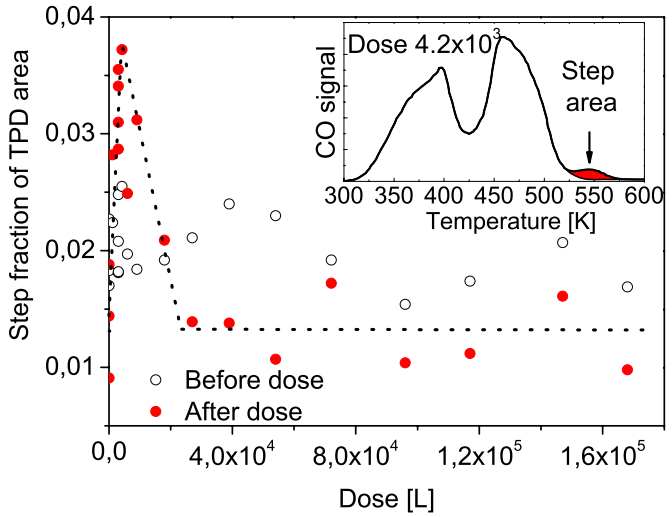

Figure 1 The amount of steps in the TPD as a function of dose. The inset shows a CO-TPD with a dose of 4.2×10^3 L, the colored area is the step fraction.

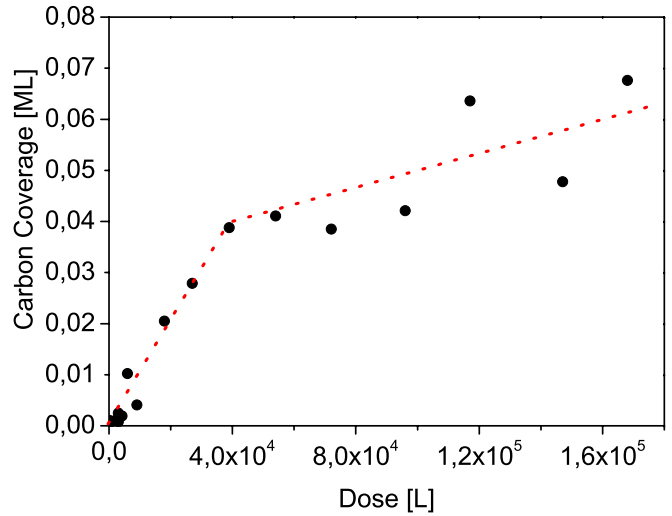

Figure 2 The carbon coverage as a function of dose. Note that the curve levels off at carbon coverage of 4%.