Report from the lecture presented by Gerhard Ertl

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The relationship between the components of the global energy system can be illustrated by Fig. 1 from the presentation “Molecules at Surfaces and Mechanisms of Catalysis” by professor Gerhard Ertl, Fritz-Haber Institut der Max Planck.Gesellshaft, Berlin.

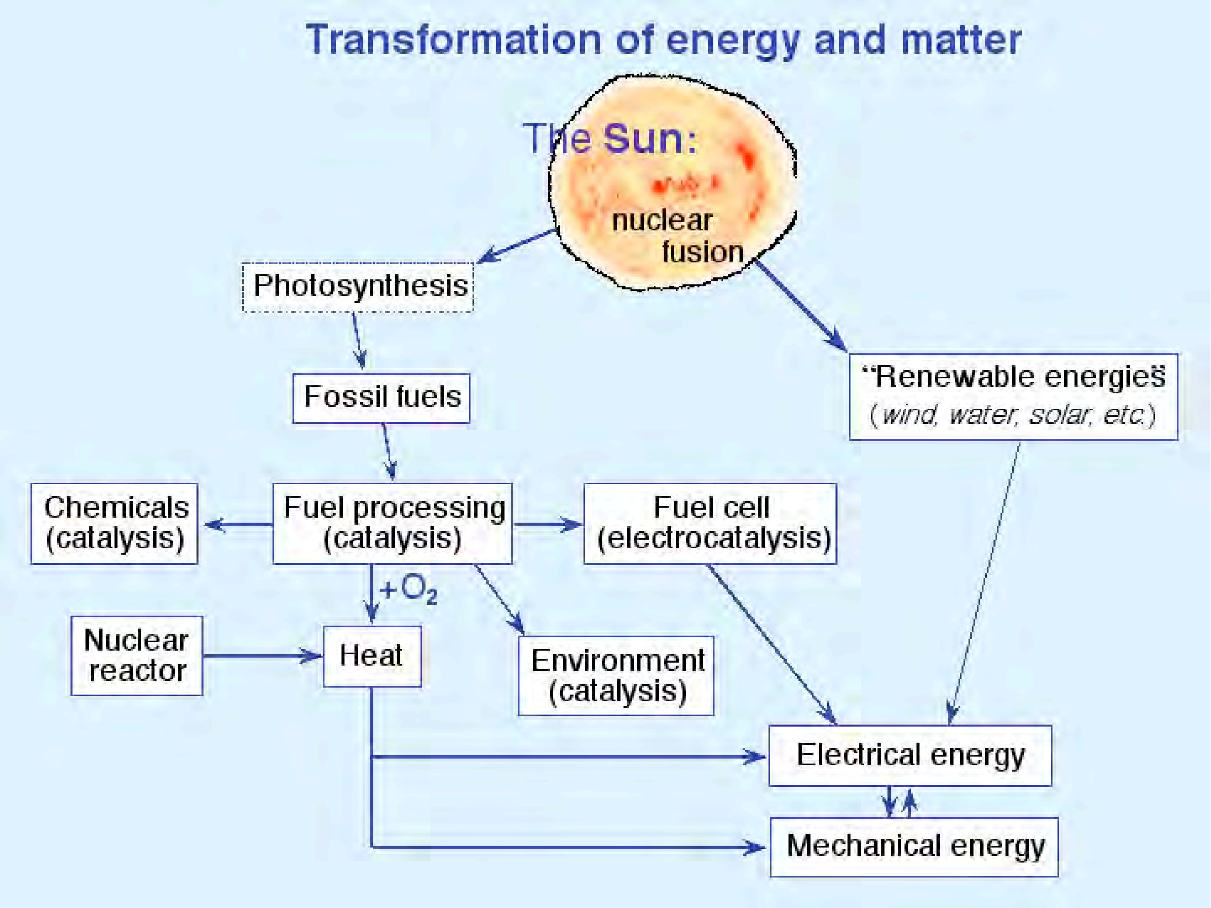


Fig. 1 (fig.2 from power point presentation)

A microscopic perspective of the energetics of chemical reactions has been given in the presentations of Zewail and Zare; professor Ertl has broadened the perspective to include also spatio-temporal self-organization, a phenomenon that results from coupling between chemical reactions and one or more of the following quantities diffusion, heat conductance, variation of partial pressures and electric field. Self-organization is important not only in surface catalysis, but also in other macroscopic systems far from equilibrium ("chemical clocks" and so-called dissipative structures). It is interesting to note that the first recognition that dissipative processes might take place in chemical systems was made by Turing in 1952 (*Phil. Trans. Roy. Soc. London, Ser. B,* 237, 37).

The exhaust catalyst in cars is perhaps the most common heterogeneous catalyst and its function is to decrease the concentration of carbon monoxide, CO, and nitrogen oxides, NO_x; Fig. 2 illustrates its function

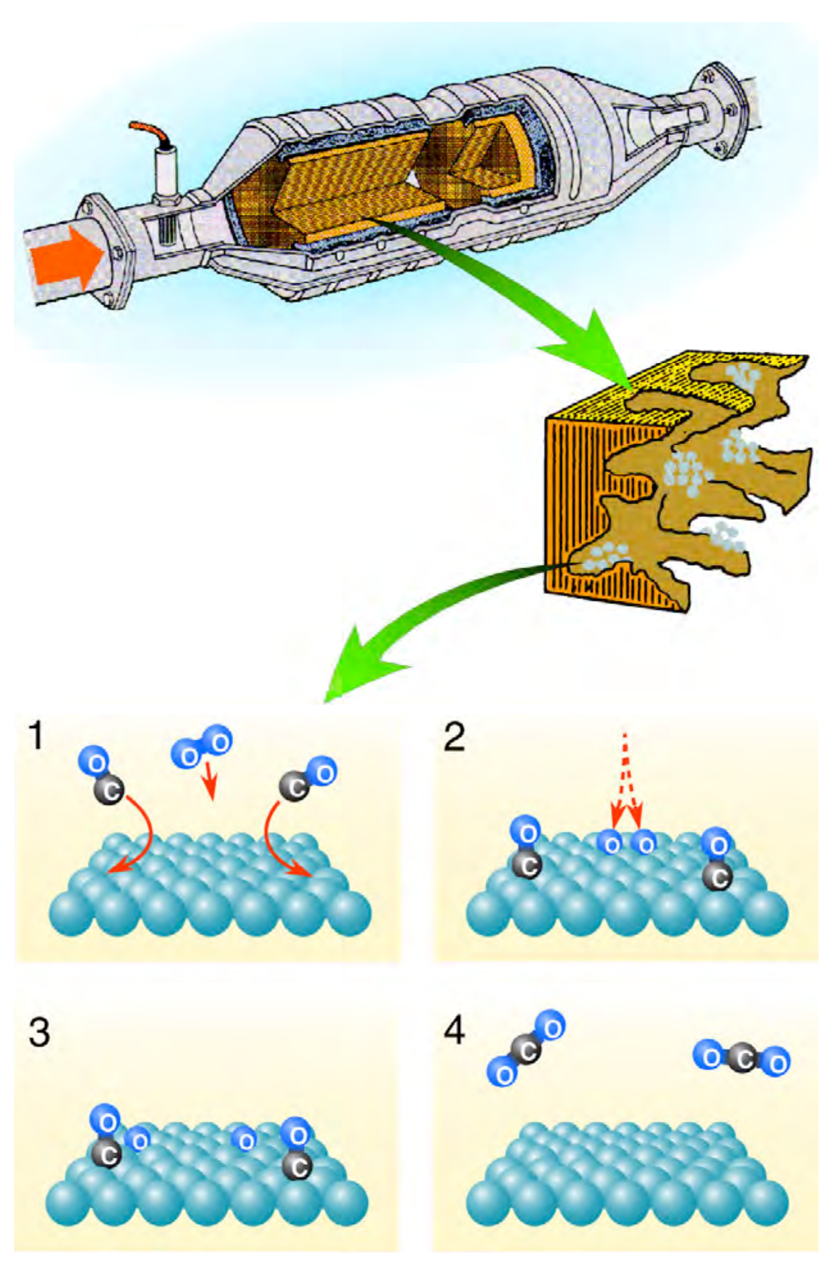
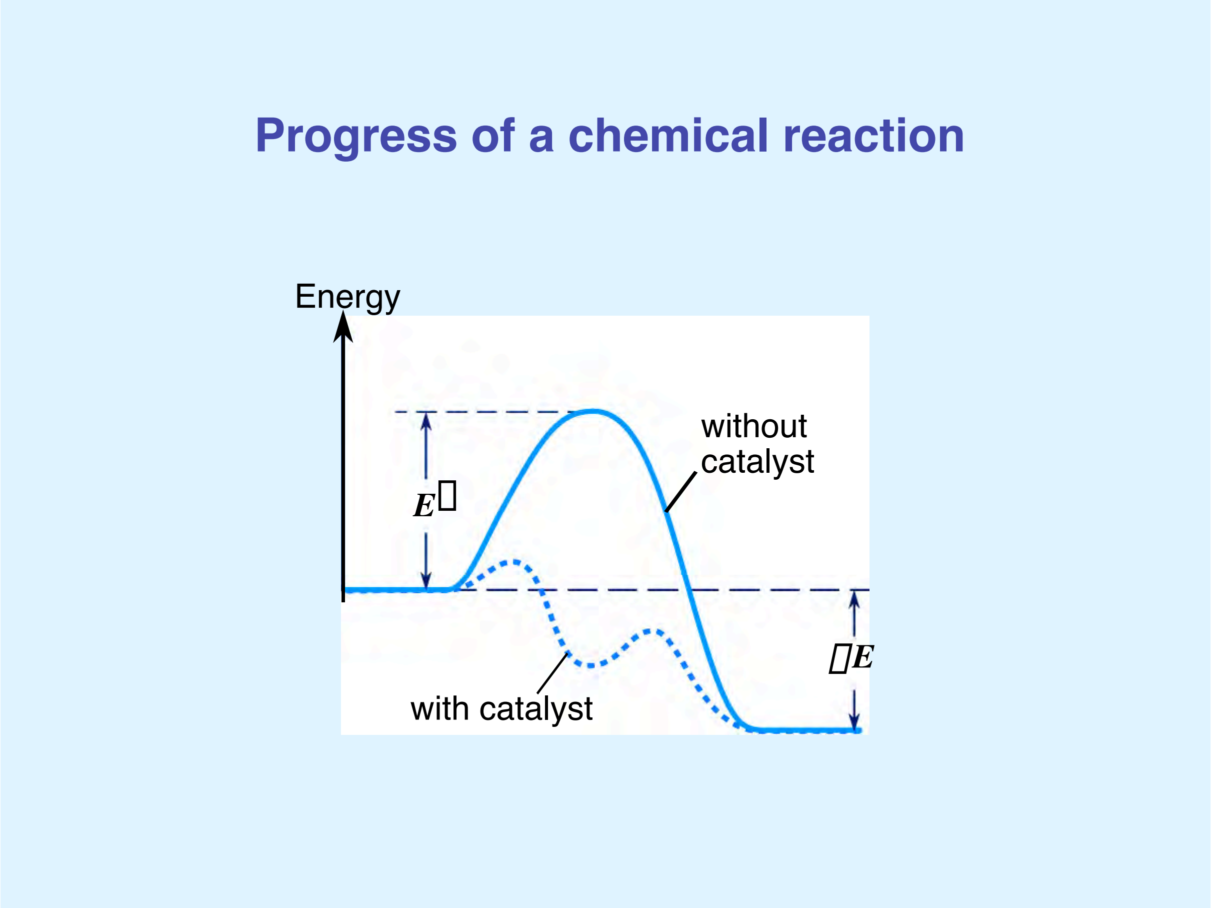


Fig. 2 (fig. 6 from power point presentation)

Ertl and his coworkers have explained the function of surface catalysis in great detail. Heterogeneous (surface) catalyst functions like other catalytic systems that is to decrease the activation energy for the chemical reaction as schematically shown in Fig. 3.



Progress of a chemical reaction

Fig. 3 (fig. 7 from power point presentation)

However, the details of the reaction, exemplified by

$2CO + O_2 \rightarrow 2CO_2$

is much more complex and involves sorption of the reacting gases on specific surface sites, dissociation of the sorbed molecules, surface diffusion and reaction and desorption of the reaction products. A cartoon of the sorption and dissociation is shown in Fig. 4.

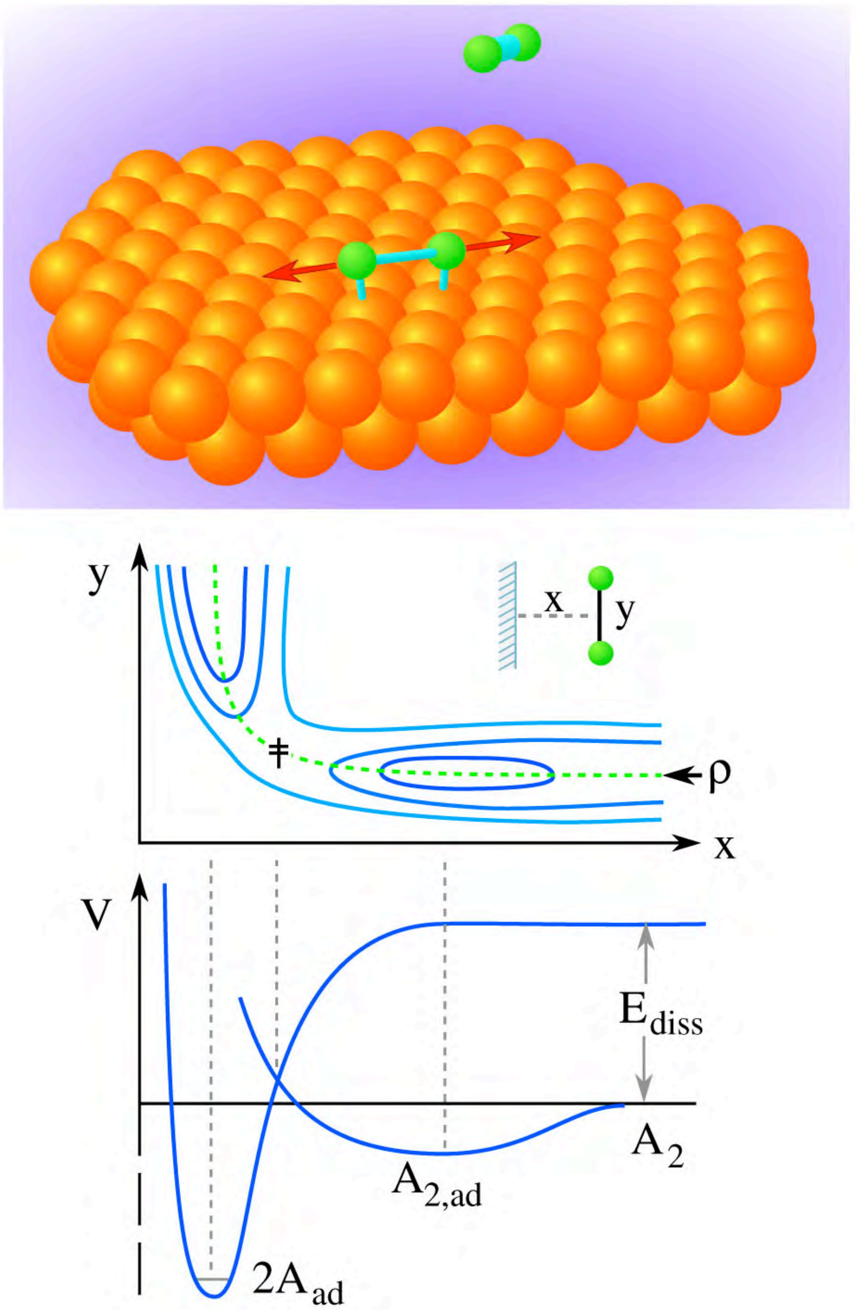
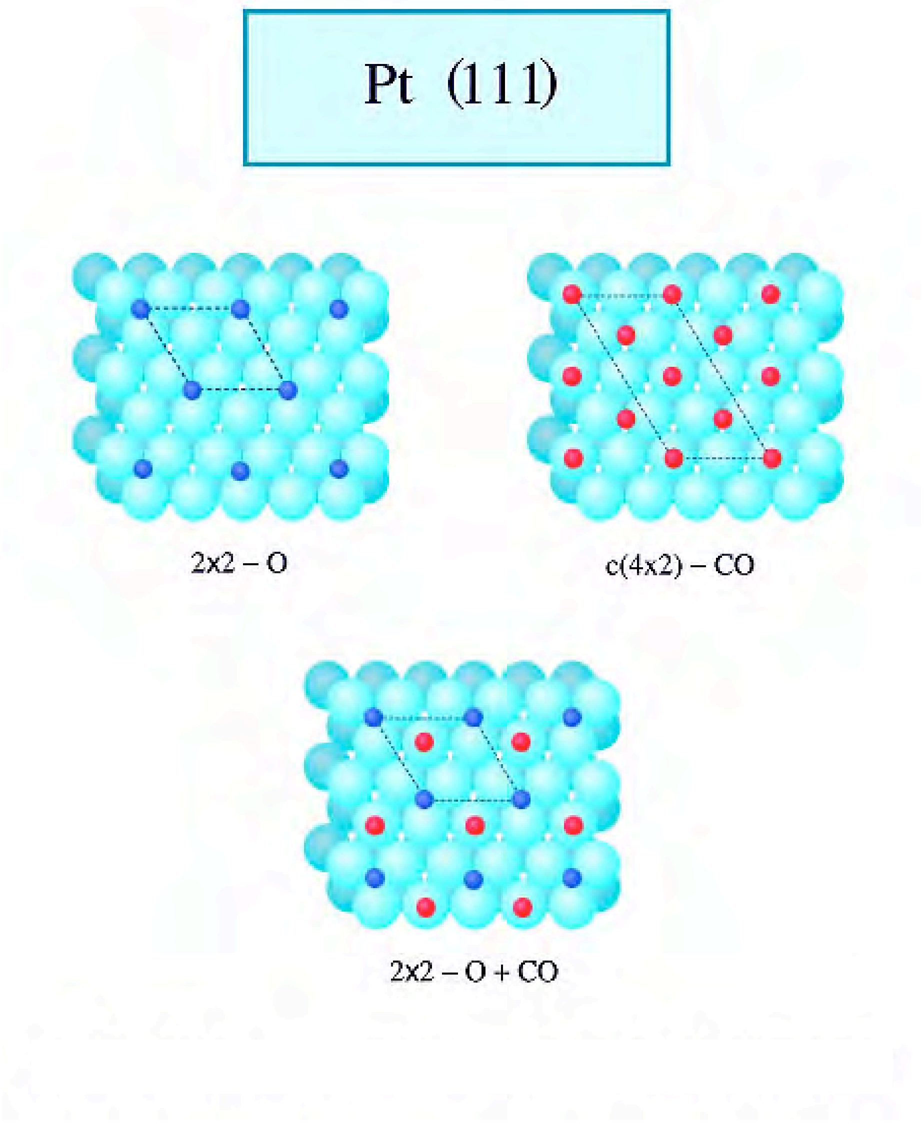


Fig. 4 (fig. 14 from power point presentation)

An experimental validation seen in Fig. 5 shows sorbed oxygen atoms on a platinum surface. A cartoon of the reaction between CO and O_2 on a platinum surface is shown in Figs. 5 and 6.



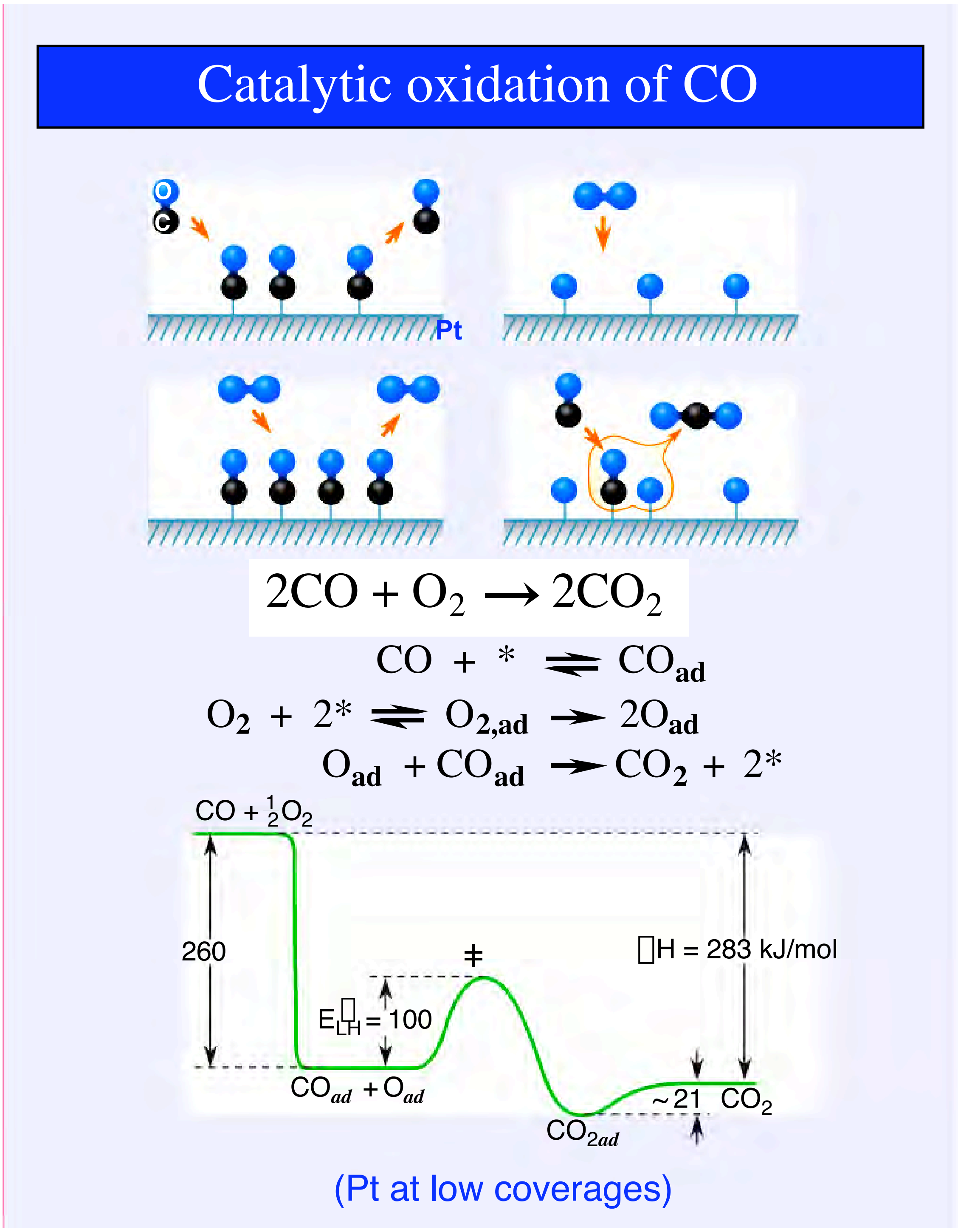
Pt (111)

2x2 – O

c(4x2) – CO

2x2 – O + CO

Fig. 5 (fig. 19 from power point presentation)



Catalytic oxidation of CO

$$2CO + O_2 \longrightarrow 2CO_2$$

$$CO + * \rightleftharpoons CO_{ad}$$

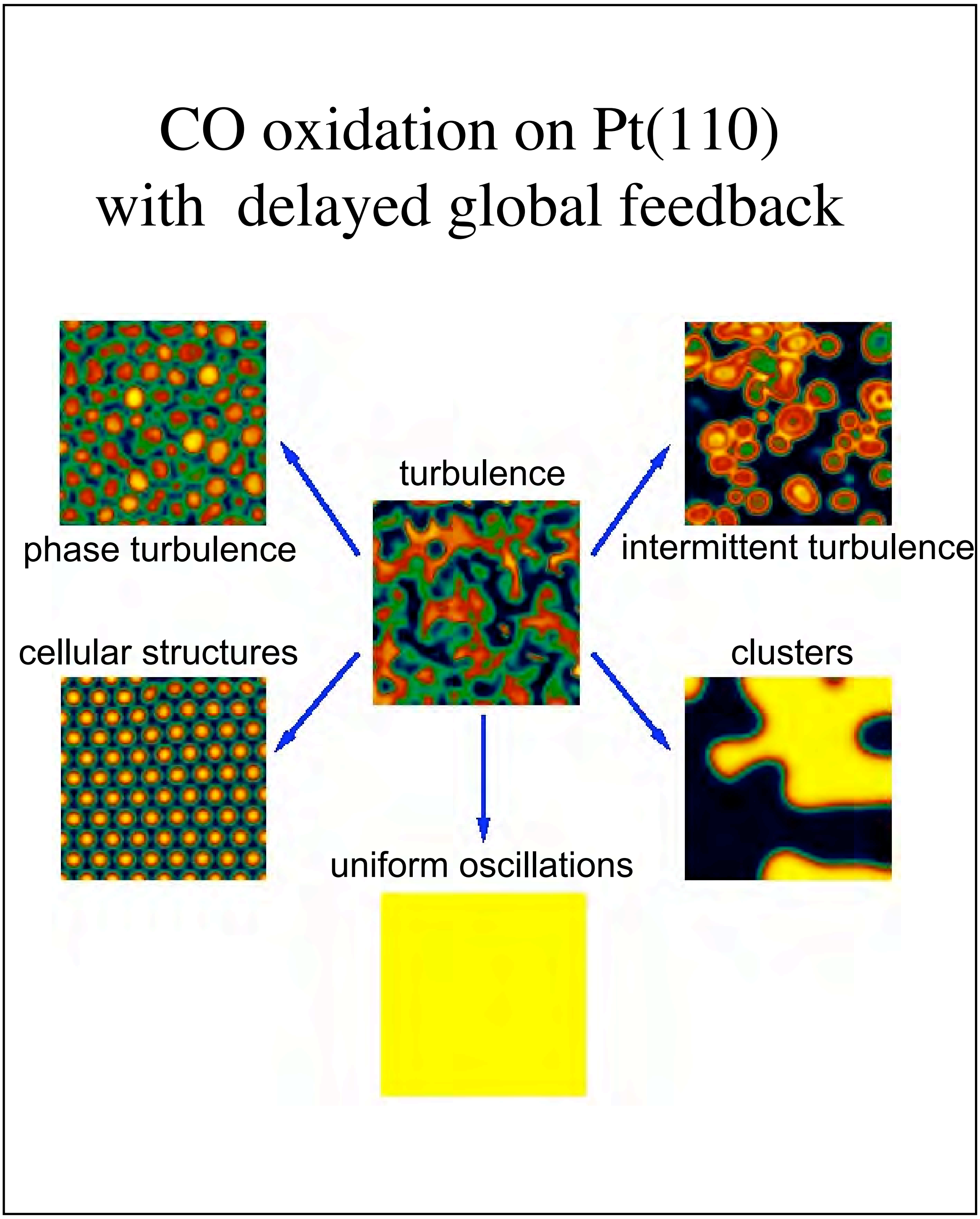
$$O_2 + 2* \rightleftharpoons O_{2,ad} \longrightarrow 2O_{ad}$$

$$O_{ad} + CO_{ad} \longrightarrow CO_2 + 2*$$

(Pt at low coverages)

Fig. 6 (fig. 20 from power point presentation)

The chemical reactions on the surface do not take place uniformly and depending on the experimental conditions a large number of “surface structures” may develop as indicated in Fig. 7.



CO oxidation on Pt(110) with delayed global feedback

turbulence

phase turbulence

intermittent turbulence

cellular structures

clusters

uniform oscillations

Fig. 7 (fig. 35 from power point presentation)

These self-organization phenomena are apparent also on the macroscopic scale was shown in a video movie, which requires special software and is not shown on this web site.