inch. The coupons were 0.215 inch in width but the corresponding test device was designed such that reactive gasses could only flow across 0.080 inch of the surface on either side of the center line of the channel's long axis. The coupons were 0.095 inch thick and made of Inconel 617.

[0327] The coupons contained 2 thermal wells to allow the metal temperature to be measured during operation. The surface features were formed from chevrons whose arms were placed at a 45° angle to the center line of the channel in its long axis (SFG0). The features themselves were each 10 mil deep and had width or opening of 15 mil. The tip of the chevron was a 10 mil round and the arms were terminated with full rounds. Flat coupons possessed an area of 0.301 in^2 for application of catalyst and the coupon with surface features possessed an available surface area for catalyst application of 0.435 in^2. These areas were used to calculate the catalyst loading per square inch (9.5 mg/in^2 of Rh on 4 mg/in^2 MgO for the flat and 10.7 mg/in^2 of Rh on 4.2 mg/in^2 MgO for the surface feature coupon). The area of each coupon exposed to the reacting gas mixture was 0.212 in^2 for the featureless coupon and 0.346 in^2 for the surface feature coupon. Prior to catalyst application the coupons were given a coating of nickel aluminide estimated to be between 10 and 20 micron thick and then subsequently heat treated to produce thin adherent scale of alumina.

Experimental—Catalyst

[0328] Catalyst was applied to the surface feature coupon by dropping 12 wt %/o $Mg(NO_3)_2$ solution onto the coupon with a pipet. The coated coupon was dried at 100° C. for 1 hour. The washcoating process was repeated once. Then the coupon was calcined at 1000° C. for 4 hours in air. The MgO loading was 4.2 mg/in^2. Next, 10 wt % hexa(acetate)-μ-oxotris(aqua) trirhodium(III)acetate solution was dropped onto the coupon. The coupon was dried at 100° C. and then calcined at 450° C. for 1 hour. The coating process was repeated to get 10.7 mg/in^2 Rh loading.

[0329] The flat coupon (having no surface features) was heated to 1050° C. in flowing H_2 at 3.5° C./min heating rate. After purging with Ar for 1 hour at 1050° C., the gas was changed to 21% O_2/Ar. The coupon was heat-treated in following O_2/Ar for 10 hours and then cooled to room temperature. An α-Al_2O_3 scale was generated on the surface after the heat treatment.

[0330] Catalyst was applied to the flat coupon dropping a 12 wt % $Mg(NO_3)_2$ solution onto the coupon with a pipet. The coated coupon was dried at 100° C. for 1 hour. The washcoating process was repeated once. Then the coupon was calcined at 1000° C. for 4 hours in air. The MgO loading was 3.7 mg/in^2. Next, 10 wt % hexa(acetate)-μ-oxotris(aqua)trirhodium(III)acetate solution was dropped onto the coupon. The coupon was dried at 100° C. and then calcined at 450° C. for 1 hour. The coating process was repeated to get 9.4 mg/in^2 Rh loading.

[0331] After preparation the flat coupon carried 9.5 mg/in^2 of Rh on 4 mg/in^2 MgO and the surface feature coupon carried 10.7 mg/in^2 of Rh on 4.2 mg/in^2 MgO. The blank coupon was also given a thin layer of alumina in a similar manner to the catalyst containing coupons but carried no catalyst.

Experimental—Conditions

[0332] One catalyst coated coupon was installed in the microchannel test device, meaning that surface features and catalyst were only present on one wall of the main channel for each test. Once the completed devices were installed in the testing infrastructure the catalysts were reduced by exposing them to a flow of 50 sccm of hydrogen and 450 sccm of nitrogen at ambient pressure and 450° C. for 2 hr. Testing was conducted at 675, 750, 800 and 850° C. The flow of methane was 150 sccm and the flow of steam 450 sccm (steam to carbon ratio was 3:1).

Results—Experimental and Simulation

[0333] The results of the experimentation conducted on both a flat and surface featured coupon can be found in Table 1 along with the results of a reactive simulation conducted in the computational fluid dynamics package Fluent™. The flat coupon was tested for approximately 53 hrs time-on-stream with nine samples taken at temperatures ranging from 673° C. to 852° C. The surface feature coupon was tested for approximately 52 hrs time-on-stream with samples taken at temperatures ranging from 671° C. to 865° C.

[0334] A test of the background activity of the system was conducted using a set of featureless (flat) coupons. The reduction step was not conducted. At conditions below 800° C. (670, 700, 718), no conversion of methane was noted. At 800° C. the conversion of methane was found to be ~4% and at 900° C. the conversion of methane was found to be ~22%.

[0335] Fluent™ simulations were conducted by constructing a calculational domain representing both a channel with out surface features this is to say a fluid domain that is 0.160" wide by 0.006" tall by 1.70" long and a similar domain at that includes surface features as described above deployed over 1.32" of the total 1.7". The reactive portion of the domain is 1.4" long, 0.15" being allowed on both inlet and outlet for to allow the flow to develop. In the reactive portion of the model SMR activity a was applied as a surface based rate and water gas shift was allowed to proceed as a volumetric rate such that it was at local equilibrium with the gas composition. In the case of SMR activity only surfaces corresponding to those on the coupons were set as catalytically active. The modeling employed the gas inlet temperatures, flow rates and outlet pressures measured in the experiments. Isothermal boundary conditions equal to the coupon temperatures were also applied.

[0336] The first kinetic level was determined using an activation energy of 169 kJ/mol and a predetermined rate form in which the rate of reforming is proportional to the partial pressure of methane raised to the 1.6 power and adjusting the pre-exponential value (rate constant) until a reasonable match was obtained between the experimental results for the featureless coupon and the prediction of the CFD model. This was set as kinetic level 1. The same procedure was applied to the data collected using the surface feature coupon and a second kinetic level established. The second level was found to be 2.1 times that of the first level.