様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科研費 KAKENHI

科学研究費助成事業　　研究成果報告書

令和　元 年　 ６ 月 ２１ 日現在

機関番号：１２３０１
研究種目：若手研究(B)
研究期間：2017～2018
課題番号：１７Ｋ１４８１９

研究課題名（和文）溶湯直接圧延を利用したポーラスアルミニウムコアサンドイッチパネルの開発

研究課題名（英文）Development of aluminum foam core sandwich panel using direct melt rolling process

研究代表者
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交付決定額（研究期間全体）：（直接経費）　　3,000,000円

研究成果の概要（和文）：ポーラスアルミニウムコアサンドイッチ（AFCS)を安価に作製する方法として溶湯直接圧延プリカーサ法を提案し，本方法を用いAFCSの作製を行うと伴にその機械的特性の評価を試みる．ADC12合金溶湯に増粘剤としてAl2O3粉末，発泡剤としてTiH2粉末を添加して撹拌し，縦型双ロール圧延機に注湯することでプリカーサを得た．プリカーサを純Al薄板またはSUS304薄板で挟みクラッド圧延することでスキン付プリカーサを得た．スキン付プリカーサを電気炉で加熱し，気孔率約50 %のポーラスアルミニウムをコア材とするAFCSの作製に成功した．AFCSの3点曲げ試験を行い，機械的特性を評価することもできた．

研究成果の学術的意義や社会的意義
プリカーサ法は高価な合金粉末を素材とし，バッチプロセスである粉末冶金技術を用いるため，この方法で作製されるAFCSは高価である．本研究ではプリカーサの作製に溶湯直接圧延を利用するため，安価な鋳塊を素材として用いることができる．加えて，生産性の良い連続プロセスである圧延を利用するため，既存のプリカーサ法と比較して安価にAFCSを作製することが可能となる．これまで，プリカーサの作製には粉末冶金の他に板材の接合技術を用いる方法も提案されている．プリカーサの作製に鋳造を含むプロセスはほとんど例がなく，濡れ性の悪い発泡剤粉末が溶湯に混ざっていくプロセスを明らかにすることは学術的にも意義深い．

研究成果の概要（英文）：Direct melt rolling precursor method is proposed as manufacturing method of aluminum foam core sandwiches (AFCS) inexpensively. I attempt to manufacture the AFCS with this method and to evaluate mechanical properties of the AFCS. Al2O3 powder as a thickening agent and TiH2 powder as a foaming agent were added to ADC12 aluminum alloy melt and then the melt was stirred. The stirred melt was poured to into a vertical type twin roll caster to obtain a foamable precursor. The precursor was put between two pure aluminum sheets or two SUS304 sheets and cladded by hot rolling to obtain a precursor with skins. The precursor with skins was heated in an electric furnace. Manufacturing AFCS with an aluminum foam core having about 50 % porosity succeeded. Three point bending test was carried out to the AFCS and the mechanical property of the AFCS could be evaluated.

研究分野：材料科学，材料力学

キーワード：ポーラスアルミニウム　サンドイッチパネル　溶湯直接圧延　双ロールキャスティング　アルミニウム　気孔率　曲げ試験　プリカーサ

Ẃr4(8S3z3ɥ3M5S4 KZ Fig. 1 &gM| (Aluminum Honeycomb Core Sandwich: AHS) AHS 4 0 M 80KS KœwKd@Su cT7[6K œ8@3M5S4KÛ (Aluminum Foam Core Sandwich: AFCS)@ IK

(Fig. 2)c 4wM• Su bDp3d$ w%IwM07§g AFCS Q 0M @M [c (Š (KMG[9Q ( )Kœ K gKS OG[Kœ8Ÿ K07§g AFCS 0[A M [c(Š Su (e(g)6 0[M8 8@07§g AFCS GcT7[6 3c.. AFCS b¥ [6 (W OSu M‰ [1] M‰ [2] [3] N6 ‰(WGc 6 AKS,N 0 v0KZ

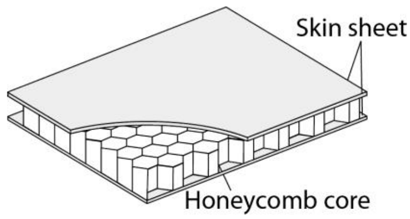

Fig.1 Aluminum honeycomb core sandwich.

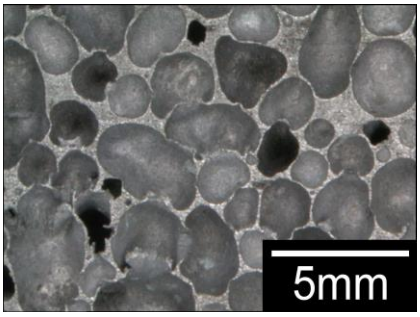

Fig.2 Cross section area of typical aluminum foam.

[1] R. Suzuki, K. Kitazono, Proceedings of Metfoam2011, (2011) 27-32.
[2] 5e(&x , 7Û , 3M5 Û 125 G&A , (2013) , .
[3] 5e(&x , 7Û , 0Y%? , M&M2015 , (2015) ,Û , E /² .

0%b% $

%[c3z3ɥS4K7§g AFCS 0‰ KZP .%K2fLMP .%Kc P/%KS5 K5b8 6P/%KS7(Š(Š(M€ dG[@A O/%IOb[9e(Š e(Š‰ G[@A(3Q06 %)[A

%[c AFCS 0KZP .%K2fLKö m%M(VcW[6

(a) Al-Si (ADC12) [6• (TiH$_2$) 9 0[A 9 m

(b) TiH$_2$ b(0Ž(Ù 400 6 54 Z c(0Ž 04 Z Kr: 4 1 8 0Ž TiH$_2$ 3Q 8 4 CaCO$_3$((0Ž(Ù 600¥)x 4 Li$_2$CO$_3$((0Ž(Ù 700¥) K • GM 3 Su MgCO$_3$((0Ž(Ù 350¥)6KZ1mS

(c)

(d) P (P1050)rSc ð (SUS304)- 0M DG[AFS 0M AFCS b Z 3 AFCS b 3 ldF0 P .%K 0 I6 AFCS b Z M

(a) (b)

Fig. 3 ADC12

4 2

Fig. 4 ADC12

873 K

ADC12 ADC12

Al_2O_3

TiH_2 $MgCO_3$

$CaCO_3$ Li_2CO_3

SIOS

(c) (d)

Fig. 5

ADC12

Al_2O_3

TiH_2

(A1050) (SUS304)

AFCS

AFCS

AFCS

AFCS

AFCS

AFCS

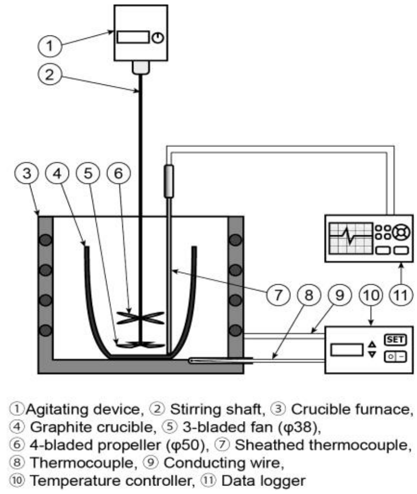

Fig.3 Experimental setup.

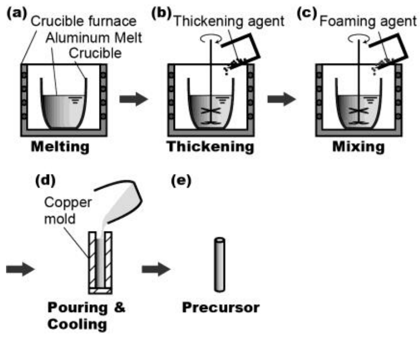

Fig.4 Manufacturing process of the precursor with casting.

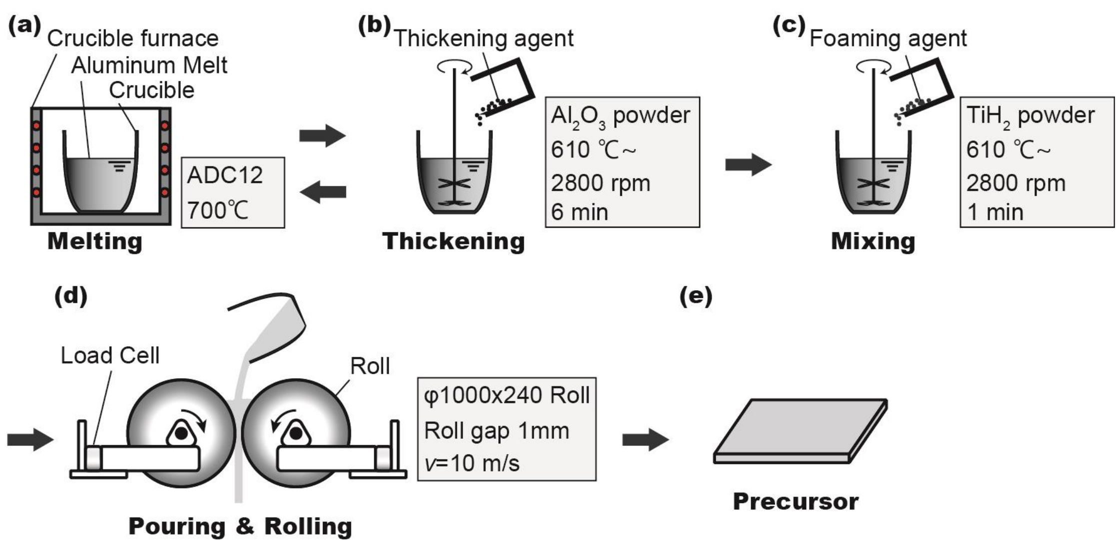

Fig. 5 Manufacturing process of the precursor with direct melt rolling.

(a) ADC12 ŐŀĸŔ
(Ş Al_2O_3 (Ŕ* TiH_2 (ŔK
5ŔŤSŔŔZ 80 %
b9Ŕ (Fig. 6)b80B̲ŔE
S54ŔKSŔ̲~80I6Û
ŔK)09)tG[ŀ
ŔÛ (Fig. 7)MGB̲ŔES>

(b) $CaCO_3$ (ŔSc Li_2CO_3 (Ž † ŔKZ ŔG\
@ 1ŕnS> ŔHŔ09Sb09&b¹
Ŕ Fig. 8 &gM>ŔbŔ09& (Û)b
ŔŔb09& (ŔŔ)bŔ
ŀ* TiH_2 (ŔKŔ*
ŔŔ|~(Ù 20 %ŔŔS> $CaCO_3$ (Š
Žc Li_2CO_3 (Ž † ŔKŔ
09&bŔ 20~30 %&[ŔŔ
ŔŕnT 10%&ŔKŔZŔ> $CaCO_3$
6ŔZ54ŔMŔYŔ[6•
G@Ŕ> Li_2CO_3 6ŔKŽ ŔŔe
† Al-Si ŔE (ADC12)} Al-Mg(A5052)K̲SGŔ
SbŔŔ(Ù 20 %Ŕ(Ù 40 %Ŕ>
Li_2CO_3 6ŔKZŔ Al-Mg ŔeMG\
ŀŔKŔA@> Li_2CO_3
bŔIOZ)tG* Li_2CO_3
† 5 mass%MG[60 %ŀbŔ
wMŔŔ0[AG@
Ŕ (Fig. 9)> TiH_2 ŔŔŽ^ Li_2CO_3 † Ŕ
KŔGŔ
bIŔ[A>

(c) ŔŔŔ Ŕ
Ŕ Fig. 10 &gM> TiH_2 Ŕ
ŔŔŀ9I6S> TiH_2 ŀ
Ŕ P .b ŔŔb TiH_2 (@
Ŕ 4Ŕr Ŕ G@1[A
SP .%ŔKŔŔZ0I6Û
ŔŔ%} Fig. 11 &gM>ŀe
B6@bŔŔ* 5 P .b(ŀ1Ž
ŔZ18ŔŀbŀŔ]ŔŔ
MŔŔ0MG@ASŔ
Ŕ 8 GbŔŔ)tŔŔ
Ŕ*~K)(ŀdŔ@
a8G@1[AS (Fig. 12)>P .%ŔŔ
8ŔG[ŀ]Ŕ(@MŔ
ŔŀbŔ Ŕ%g)~
K)09)tG[* Fig. 13 &gM|)Ŕ -
fNsd)zŔG[)ŔŔMG@A
S>

(d) P Ŕ ŔŔŔ 0.3 mm b
SUS304 ŔLI 1.0 mm b A1050 Ŕ
† ŔKZ0KS Ŕ b
Ŕŀ~%} Fig. 14 (a)ŀ Fig. 14 (b)_ ŔE &g
M>]UŀŔ
Ŕd7Ŕ80MG@AS> SUS304 Ŕ
KZ0KS AFCS b Â 8Ŕ~09)Ŕ Fig.
15 &gM>P .%ŔŔŔ
ŔMŔ80_
B ŔES> SUS304 Ŕ AF CS ŀ A1050 Ŕ
Ü AFCS 6ŔZ 3 ldF09)t* Fig. 16 &gMd
FŔ -Ŕ)zŔG[* AFCS bdF
IŔMG@AS>

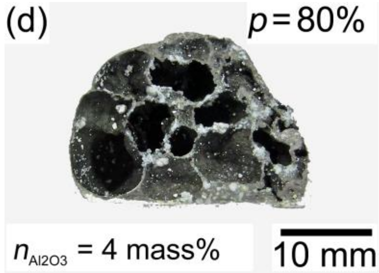

Fig.6 Cell morphology of an aluminum foam manufactured with casting precursor method.

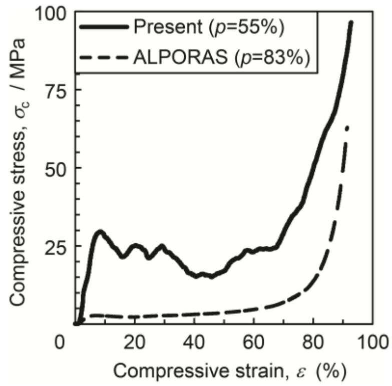

Fig. 7 Compressive stress – strain curve for a present aluminum foam and a commercial aluminum foam (ALPORAS).

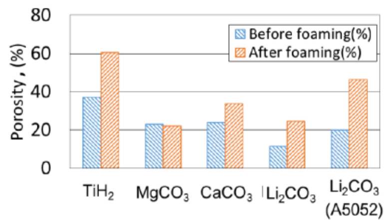

Fig. 8 Mean porosities of the precursors and foams for various foaming agents.

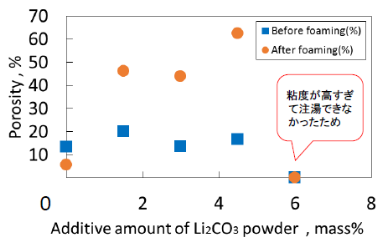

Fig. 9 Mean porosities of the precursors and foams for Li_2CO_3.

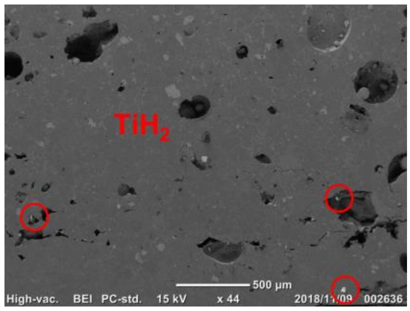

Fig. 10 SEM micrograph of the precursor.

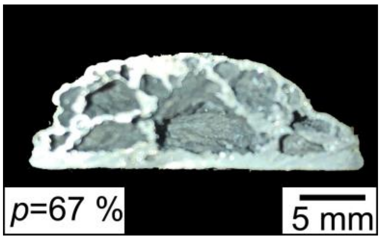

Fig. 11 Cell morphology of the aluminum foam manufactured with direct melt rolling method.

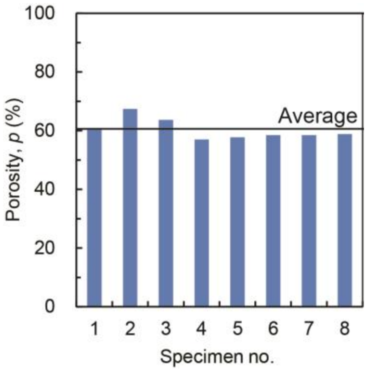

Fig. 12 Variation in the porosity of the aluminum foams manufactured with direct melt rolling method.

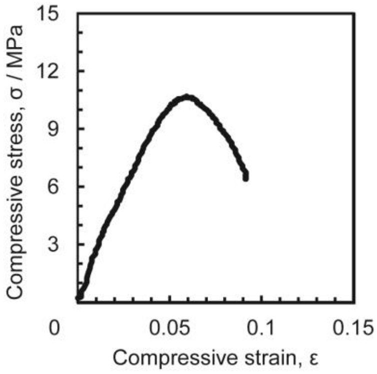

Fig. 13 Compressive stress – strain curve for a present aluminum foam.

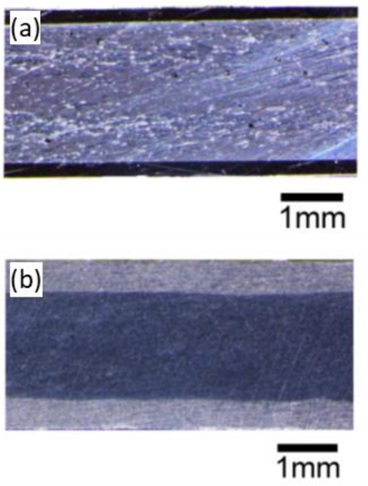

Fig. 14 Stereomicrographs of the precursors with (a) SUS304 skins (0.3 mm thickness) and (b) A1050 skins (1.0 mm thickness).

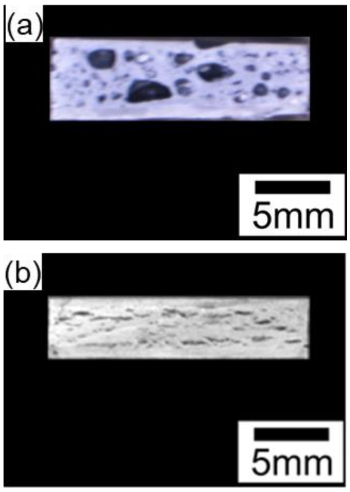

Fig. 15 Stereomicrographs of the AFCS with (a) SUS304 skins (0.3 mm thickness) and (b) A1050 skins (1.0 mm thickness).

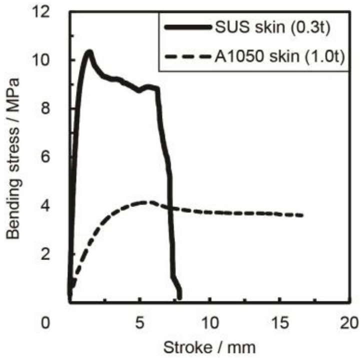

Fig. 16 Bending stress – stroke curve for a present aluminum foam core sandwich.

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[1] 5e(&x, 0Y%? , 1&ž , ,4sµ , Ņ 7Û , “ ”, 5 Û , 82, 9 (2018), 349-357.(1w)

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[1] Q õ , ,6E¾ , Ņ7Û , 5e(&x, “ ”, %Èv 2018, 54Š9 , (2018ƒ12), E9? , . (1 !)

[2] 5e(&x, 0Y#M , ,6E¾ , Ņ 7Û , “ ”, ' 135 G&A , 3M5 Û , (2018ƒ11), ¾ , 8E . (1 !)

[3] Q , ,6E¾ , Ņ7Û , 5e(&x, , 9 , 9 ¡ , (2018ƒ10), ¾ , Ï . (1 !)

[4] 5e(&x, 0Y%? , Ņ 7Û , “ Al-Mg B0 ”, 2018 n ‡ , 5 Û , (2018ƒ3), ¾ , 8E . (1 !)

[5] 5e(&x, Ņ 7Û , 0Y%? , “ ”, 2017 &An ‡ , 5 Û , (2017ƒ9), 4(, 8E /² . (1 !)

[6] 0Y%? , Ņ7Û , 5e(&x, “ ”, %Èv 2017, 54Š9 , (2017ƒ 12), E9? , . (1 !)

[7] .6E¾ . Ņ7Û , 5e(&x, , “ ADC12 ”, , ¥64Š , (2017ƒ10), ¾ , . (1 !)

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